# A PROSPECTIVE STUDY ON SHORT TERM FUNCTIONAL OUTCOME ANALYSIS OF INTERNAL FIXATION OF DISTAL ULNA FRACTURES WITH CONCOMITANT DISTAL RADIUS FRACTURES

*Dissertation submitted to*

**M.S. DEGREE-BRANCH II**
**ORTHOPAEDIC SURGERY**

**THE TAMILNADU DR. M. G. R. MEDICAL UNIVERSITY**
**CHENNAI-TAMILNADU**

**APRIL 2013**

# CERTIFICATE

This is to certify that this dissertation titled **"Short Term Functional Outcome Analysis of Internal Fixation of Distal Ulna Fractures with Concomitant Distal Radius Fractures"** is a bonafide record of work done by **DR. S. BALASUBRAMANIAM,** during the period of his Post graduate study from May 2011 to November 2012 under guidance and supervision in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-600003, in partial fulfillment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree Examination of The Tamilnadu Dr. M.G.R. Medical University to be held in April 2013.

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# DECLARATION

*I declare that the dissertation entitled* **"SHORT TERM FUNCTIONAL OUTCOME ANALYSIS OF INTERNAL FIXATION OF DISTAL ULNA FRACTURES WITH CONCOMITANT DISTAL RADIUS FRACTURES"** *submitted by me for the degree of M.S is the record work carried out by me during the period of* ***May 2011 to November 2012*** *under the guidance of* ***PROF.M. R. RAJASEKAR*** **M.S.ORTHO.,D.Ortho.,** *Associate Professor of Orthopaedics, Institute of Orthopaedics and traumatology, Madras Medical College, Chennai. This dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfillment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2013.*

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# CONTENTS

# INTRODUCTION

Fractures of distal radius are most common fractures of the upper extremity forming about 17 % of all fractures. Distal radial fractures have a bimodal age distribution, consisting of a younger patients sustaining injury due to relatively high-energy trauma and an elderly patients sustaining low energy trauma. Around 50-70 % of the distal radius fractures are associated with distal ulna fractures following a rise in the high energy trauma in recent years. The treatment of distal radius fracture has seen a tremendous evolution from cast immobilization through Kirschner wire fixation to internal fixation with various plates. The significance of distal ulna fractures is often not appreciated and treated inadequately in comparison to its larger counterpart; the radius.

The goals of the treatment of distal radius fractures are to restore joint line congruity, joint stability and alignment with minimal soft tissue dissection to allow for early mobilization and establishment of good function, but this early mobilization cannot be undertaken confidently without a stable distal ulna and distal radio ulnar joint.

The evolution of three column concept of the distal radius and ulna enlightened the importance of the distal ulna and the necessity of its fixation along with its counterpart. Cadaver studies and biological loading studies of the wrist showed the higher transmission of load across the ulnar side and hence the concepts in the fixation of the distal ulna came forth.

Ulnar-sided injuries of the wrist have received more attention recently for their potential negative impact on the outcome of distal radius fractures. Some studies have revealed that inappropriate treatment of distal ulna fractures with appropriately treated distal radius fractures resulted in distal radio ulnar joint instability and hence poor functional outcome at later years. There have been proponents for both operative and non-operative methods. Various studies are coming forth with various fixation techniques being described for distal ulna fractures with concomitant distal radius fractures. Good functional results were reported with either modality in low energy fractures in elderly but the ideal treatment for high energy injuries with associated distal ulna fractures is still being debated.

This justifies a separate review on internal fixation of distal ulna fracture with concomitant distal radius fractures.

# AIM OF THE STUDY

To analyse the short term Functional Outcome following internal fixation of distal ulna fractures with concomitant distal radius fractures done in our Institute of Orthopaedics and Traumatology, Madras medical College and Rajiv Gandhi Government General Hospital between the period of May 2011 and November 2012.

# HISTORICAL REVIEW

Fractures of the distal radius have been extensively studied in literature for over two centuries. Hippocrates in the early eighteenth century diagnosed any displacement of the wrist following injury as dislocation due to the absence of fracture symptomatology like crepitus, paradoxical mobility, edema etc.

**Pouteau**[2], a French surgeon at the end of 18th century made clear that they were almost always mistakenly diagnosed as wrist dislocations, when in the reality they were fractures of the distal end of radius.

**Abraham colles**[3] an Irish surgeon in 1814 described the dorsally displaced distal radius fracture that bears his name. He stated "One consolation only remains, that the limb will at some remote period again enjoy perfect freedom in all of its motions and be completely exempt from pain: the deformity, however, will remain undiminished through life"

**Dupuytren**[1], a French surgeon in 1834, based on numerous post mortem anatomical studies, proved that the majority of the injuries in doubt were actually fractures, mainly dorsally displaced.

**Barton** from USA[5] in 1838 defined the transected type of fracture, by implementation of force when the hand is at volar flexion, with the line of the fracture passing obliquely intraarticularly, detaching and separating a volar intraarticular fragment, with only part of the dorsal margin to participating.

**Smith**, Irish surgeon in 1847[4] described fracture with anterior displacement, as a result of falling with the hand in volar flexion that was named after him.

**Jones (1915)**[6] suggested a closed manipulation technique for reduction by increasing the deformity, giving traction and immobilizing in reduced position.

**Connolly (1995)**[8] reduced the fractures by reversing the original mechanism of injury.

**Anderson and O'Niel (1944)**[21] described the principles of ligamentotaxis for the use of external fixators in distal radius fractures. The external fixator acts as a neutralization device and to maintain traction.

**Charnley et al in 1950**[9] described three point contact for cast immobilization. The three points were dorsally over the dorsal fragment, volarly and dorsally over the forearm and volarly over the distal aspect of proximal fragment.

**Lambotte in 1964**[12] proposed pinning of radial styloid for maintaining purchase in distal radius fractures.

**Ellis in 1965** studied Open reduction and internal fixation of unstable Smith's or volar Barton fracture with T shaped plate which was devised by him.

**Agee (1993)**[21] stated that volar translation of the hand brings back volar tilt.

**Frykman (1967)**[17] first described distal ulna fractures associated with distal radius fractures. He reported that fall on the outstretched hand with the wrist joint in 40° to 90° of extension produces dorsally displaced distal radius fracture. He established an eponymous classification system, which defines the fracture as intra-articular or extra-articular. It also describes the involvement of radiocarpal and distal radioulnar joints along with the presence or absence of ulnar styloid process fracture.

**Melone (1984)** [21] proposed a classification by describing four components of the radiocarpal joint and five patterns in intra articular fractures.

**Sarmiento and associates (1975)**[10] recommended plaster immobilization in supination, if distal radioulnar joint was found to be involved.

**Kapandji in 1976** [13] proposed two pin intrafocal pinning.

**Weber in 1987**[11] described the bending mechanism and its relation to the fracture pattern of the distal radius. He also stated that collapse of the fracture is unavoidable due to pull of flexor and extensor tendons.

**John M. Rayhack in 1989** and again in **1991**[14] proposed the technique of ulnar- radial wiring to immobilize the distal radio-ulnar joint supplementing the ligamentotaxis.

**John k.Bradway (1989)**[13] retrospectively reviewed results in 16 patients treated by open reduction and internal fixation and concluded that internal fixation is the treatment of choice for displaced, comminuted intra articular fractures.

**Bartosh and Saldana in 1990**[15]stated that the technique of closed traction and reduction will not accurately restore palmar tilt due to thick palmar ligaments as compared to dorsal ligaments.

**James shaw et al in 1990**[38]conducted a biomechanical study and opined primary repair of displaced ulnar styloid avulsion fractures is essential for a stable distal radio ulnar joint.

**Metz and Gilula in 1993**[22] stated that, all distal radius fractures should undergo postero-anterior and lateral view x-rays.

**Rikkli et al in 1996**[16] described the three column concept of the wrist. He stated that the ulnar column serves as an axis of rotation for forearm and important load transmitter next to the middle column.

**Louis W. Catalano III, et al. (1997)**[24] did a retrospective study to determine thelong term functional and radiographic outcomes in a series of young adults treated with open reduction and internal fixation and concluded that outcome of a distal radial fractureis largely determined by its type.

**Fitoussi F, et al. (1997)**[25]in their study of 34 patients with intra-articular fracturesof the distal radius treated with open reduction and internal fixation with buttress plateand screws, concluded that the potential for restoration of normal alignment and stabilityof fixation are the main advantages of internal fixation with plates.

**Carter PR, et a1. (1998)**[26] evaluated a new method of internal fixation of unstable distal radius fractures using an anatomically pre shaped, rigid dorsal low profile plate with recessed screw holes along with autogenous bone graft and concluded that patients with unstable fractures benefited with the new plate.

**Jakob M, et al.(2000)**[27] conducted a study on 76 patients and recommended a double plating method with 2 mm titanium plates, for dorsally displaced fractures, where open reduction is indicated to restore congruency and extra-articular anatomy. It is reliable in providing stable internal fixation and allowing early function.

**Megan et al (2002)**[31]demonstrated that the ulnar styloid fractures with significant displacement, associated with distal radius fractures increased the risk of later distalradioulnar joint instability.

**Louis W.Catalano, et al.(2004)**[28] assessed the articular displacements of distal radius fractures and stated that current operative indications include fractures with radiocarpal or distal radioulnar joint step or gap deformities greater than l-2mm, gross distal radioulnar joint instability or those with extensive metaphysealcomminution. In general, there is tendency to lean toward operative fixation in younger, more active patients.

**Ring D et al in 2004**[35]stated condylar blade plate fixation of unstable distal ulna fractures associated with distal radius fractures gave good alignment and satisfactory results.

**Nana AD et al (2005)** [23] gave guidelines for acceptable reduction with parameters including radial inclination, radial height, palmar tilt and articular incongruity.

**Szabo (2006)**[18] stated that, in addition to the triangular fibrocartilage complex (TFCC), further stability to distal radio ulnar joint is provided by pronator quadratus, extensor carpi ulnaris, joint capsule and interosseous membrane.

**Walz et al in 2006**[36] described minimally invasive fixation of distal ulna fractures associated with distal radius fractures using elastic stable intramedullary nailing.

**Haugstvedt JR et al in 2006**[34] studied the relative contributions of the ulnar attachments of the TFCC to the distal radioulnar stability and proclaimed its significance.

**Schnall Stephen B et al (2006)**[29] evaluated the advantages of newer method of internal fixation with fracture specific implants and stated that they provided stable fixation with good functional outcome.

**RohitArora et al (2007)**[30] analyzed internal fixation with 2.4 mm locking compression plate and claimed superior stability with maximum number of screws in metaphyseal segment.

**Dennison DG in 2007**[37]stated that open reduction and internal locked plate fixation of unstable distal ulna fractures with concomitant distal radius fracture gave good to excellent alignment and motion with near symmetrical grip strength with minimal transient morbidity.

**Belloti et al in 2010**[32]demonstrated poor outcomes of distal radius fractures associated with ulnar styloid fractures left untreated following a randomized control study.

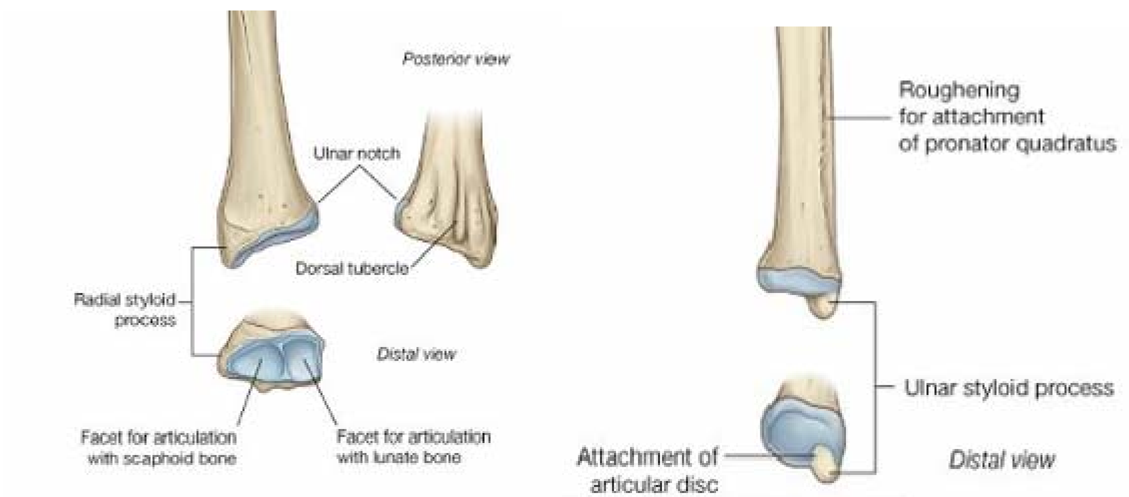
**Brian foster et al in 2012**[33] studied a new technique of intrafocal pin placement for distal ulna fractures associated with distal radius fractures.

# APPLIED ANATOMY

The word wrist is derived from the word ‘WRAESTON’ meaning to twist. The wrist joint proper includes distal 4-5cms of radius, distal ulna and proximal row of carpus. It encompasses radio carpal joint, ulno carpal joint and distal radio ulnar joint.

## Skeletal anatomy:

The distal radius consists of the (a) metaphysis, (b) scaphoid facet, (c) lunate facet, and (d) sigmoid notch. The distal articular surface of the radius is concave in both the sagital and coronal planes, and is normally declined 10 - 15º palmarly and 15 - 25º ulnarly. There are two fossae or facets that articulate with the proximal surfaces of the scaphoid and lunate. The scaphoid fossa is triangular pointing radially, and is larger than the more quadrangular lunate fossa, located on the ulnar side of the radius. The metaphysis is flared distally in both the AP and the lateral planes with thinner cortical bone lying dorsally and radially. The significance of the thinness of these cortices is that the fractures typically collapse dorsoradially. In addition, the bone with the greatest trabecular density lies in the palmar ulnar cortex. The fact that this bone is thicker even in osteoporotic cadaver specimens may explain the success of internal fixation techniques, which take advantage of this superior bone. Distally, the radius has a somewhat trapezoidal shape. The radial styloid rotates palmarly 15 degrees off the axis of the radius, which makes capture difficult from a dorsal approach. The strongest bone is found under the lunate facet of the radius. The line of force passes down the long finger axis through the capitolunate articulation and contacts the radius at this location[41]. The palmar ulnar corner is often referred to as the keystone of the radius. It serves as the attachment for the palmar distal radioulnar ligaments and also for the stout radiolunate ligament.



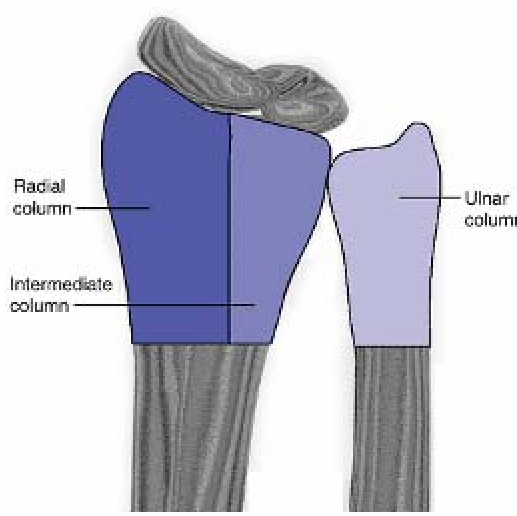

Skeletal anatomy of distal radius and distal ulna

The distal ulna consists of ulnar head and styloid process. The ulnar head is the distal end of the ulna articulating with the sigmoid notch of the distal radius. The ulnar head acts as the pivot around which the distal radius rotates during the rotational movements of the forearm. The ulnar styloid is another important element of the bony anatomy of the DRUJ. It is a continuation of the subcutaneous ridge of the ulnar shaft and stands as a strut on the end of the ulna to stabilize the ulnar soft tissues of the wrist. The sheath of the extensor carpi ulnaris, the ulnocarpal ligaments: ulno lunate, ulnotriquetralulnocapitate ligaments, and the triangular fibrocartilage all attach to the distal ulna and help maintain the congruency of the DRUJ; most of these attachments are at the base of the ulnar styloid.

Rikkli et al proposed the three column concept of the wrist, each of which is subjected to different forces and must be addressed as discrete elements[16]. The radial column consists of the scaphoid fossa and the radial styloid. Due to the radial inclination of 22 degrees, impaction of the scaphoid on the articular surface results in a shear moment on the radial styloid causing failure laterally at the radial cortex. The radial column, therefore, is best stabilized by buttressing the lateral cortex.

The intermediate column consists of the lunate fossa and the sigmoid notch of the radius. The intermediate column is the keystone of the radius in maintaining the articular congruity and the function of the distal radioulnar joint. Failure of the intermediate column occurs as a result of impaction of the lunate on the articular surface with dorsal comminution. A direct buttress of the medial aspect of the radius stabilizes the column.

The ulnar column consists of the ulna styloid, but also should include the TFCC and the ulnocarpal ligaments. Significant forcesof around 50% are transmitted across the ulnar column, especially while making a tight fist[16,38].




Three columns of the distal radius and ulna

## Ligamentous anatomy:

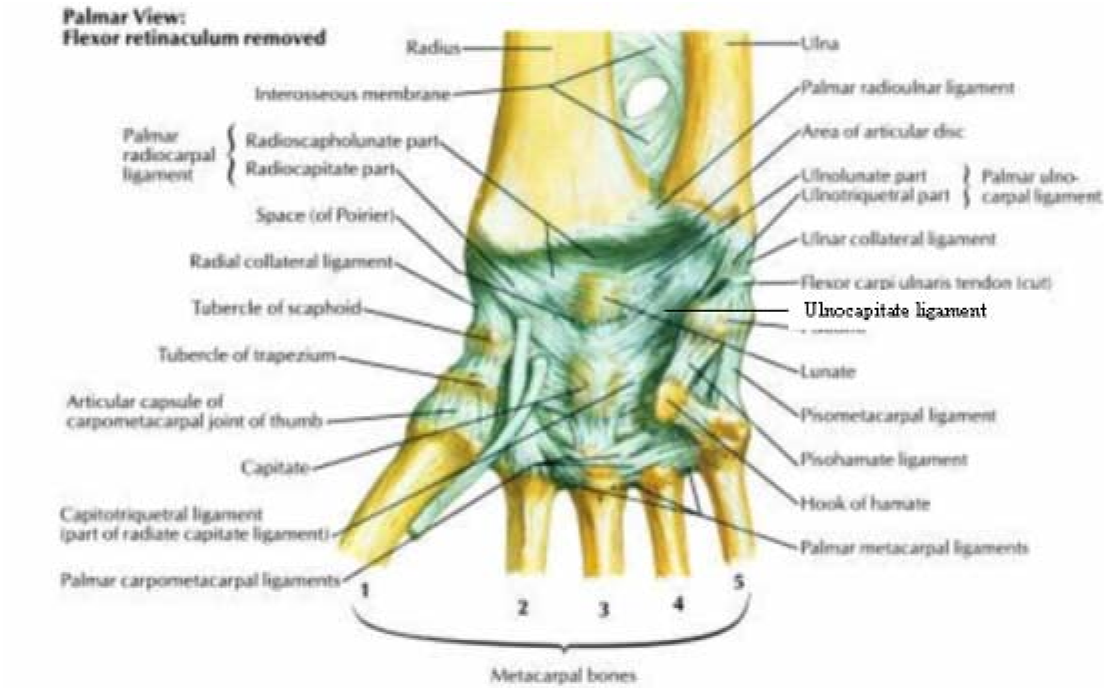
The extrinsic ligaments of the wrist play a major role in the use of indirect reduction techniques. The palmar extrinsic ligaments are attached to the distal radius, and these ligaments are relied on to reduce the components of a fracture using closed methods. There are two factors about these ligaments that make them significant for reduction. First, the orientation of the extrinsic ligaments from the radial styloid is oblique relative to the more vertical orientation of the ligaments attached to the lunate facet[15].

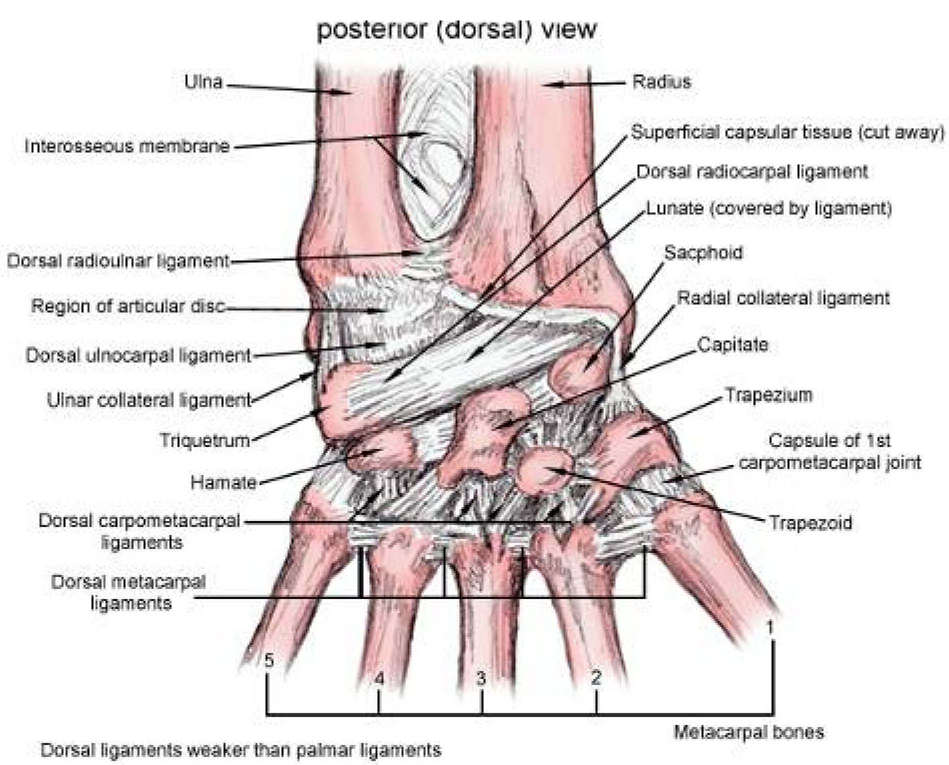
The second significance of the ligamentous anatomy is due to the relative strengths of the thicker palmar ligaments when compared with the thinner dorsal ligaments. In addition, the dorsal ligaments are aligned in Z manner, which makes them lengthen at lesser force than the palmar ligaments. The significance is that distraction will result in the palmar ligaments becoming taut before the dorsal ligaments. Thus, the palmar cortex is brought out to length before the dorsal cortex. It is for this reason that it is difficult to achieve reduction of the normal 12 degrees of palmar tilt using distraction alone[15].

The ulnotriquetral, ulnocapitate and ulnolunate ligaments also are considered part of the TFCC. They share a common origin from the region of the ulnar styloid base and fan out past the triangular fibrocartilage to insert on the triquetrum, capitate and lunate, respectively. The ligaments are important stabilizers of the ulnar corner of the wrist and resist palmar and ulnar displacement of the carpus, particularly in power grip[34,38].

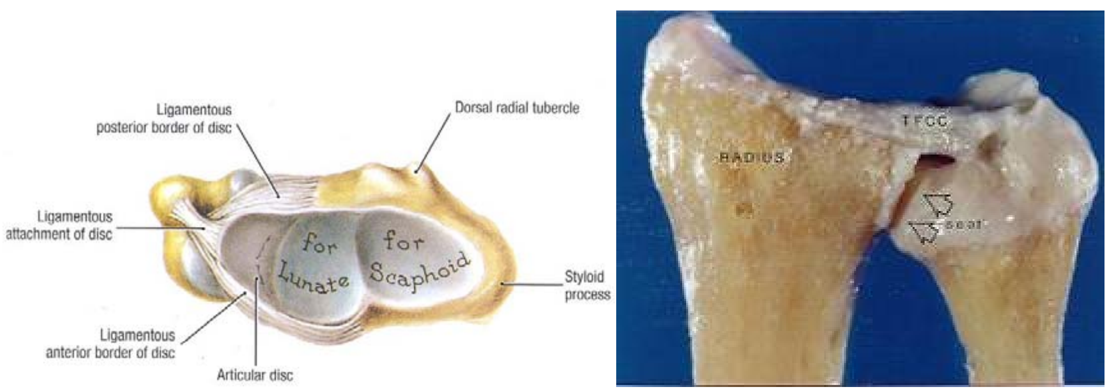
# LIGAMENTS OF THE WRIST

## Anterior (palmar) view



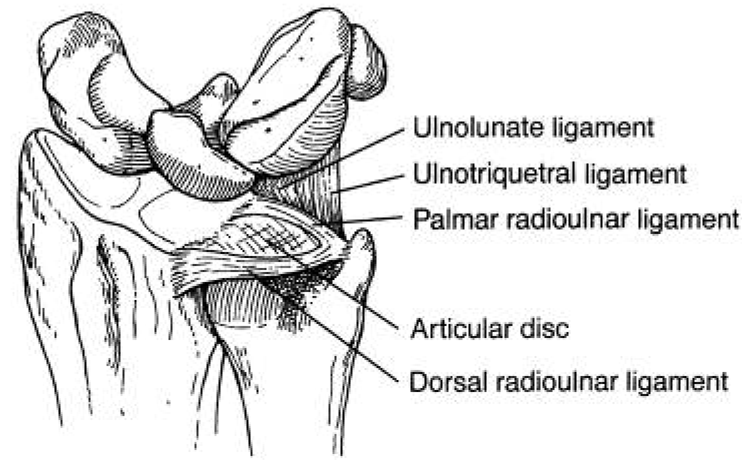



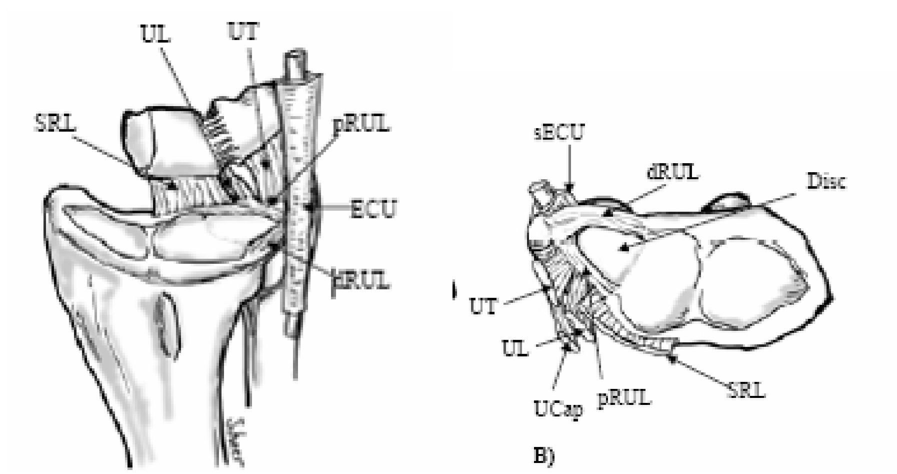
One of the most important structures is the triangular fibrocartilage complex (TFCC), a term coined by Palmer and Werner. It arises from the ulnar aspect of the lunate fossa of the radius and courses ulnarward to insert into the base of the ulnar styloid. It also flows distally, where it is joined by fibers arising from the ulnar aspect of the ulnar styloid and inserts distally into the triquetrum, hamate, and base of the fifth metacarpal. In the center of the complex is the triangular fibrocartilage (TFC) proper[34]. The periphery of the TFC is thickest, usually measuring 5 mm, and is the portion best suited to bear tensile loads. The rim is well vascularized and therefore has good healing potential.




Triangular fibro cartilage and its components

**Triangular Fibro cartilage Complex and its components**




UL- Ulnolunate ligament
UT- Ulnotriquetral ligament
pRUL & dRUL – Radioulnar ligament
UCap – Ulnocapitate ligament
ECU- Extensor carpi ulnaris

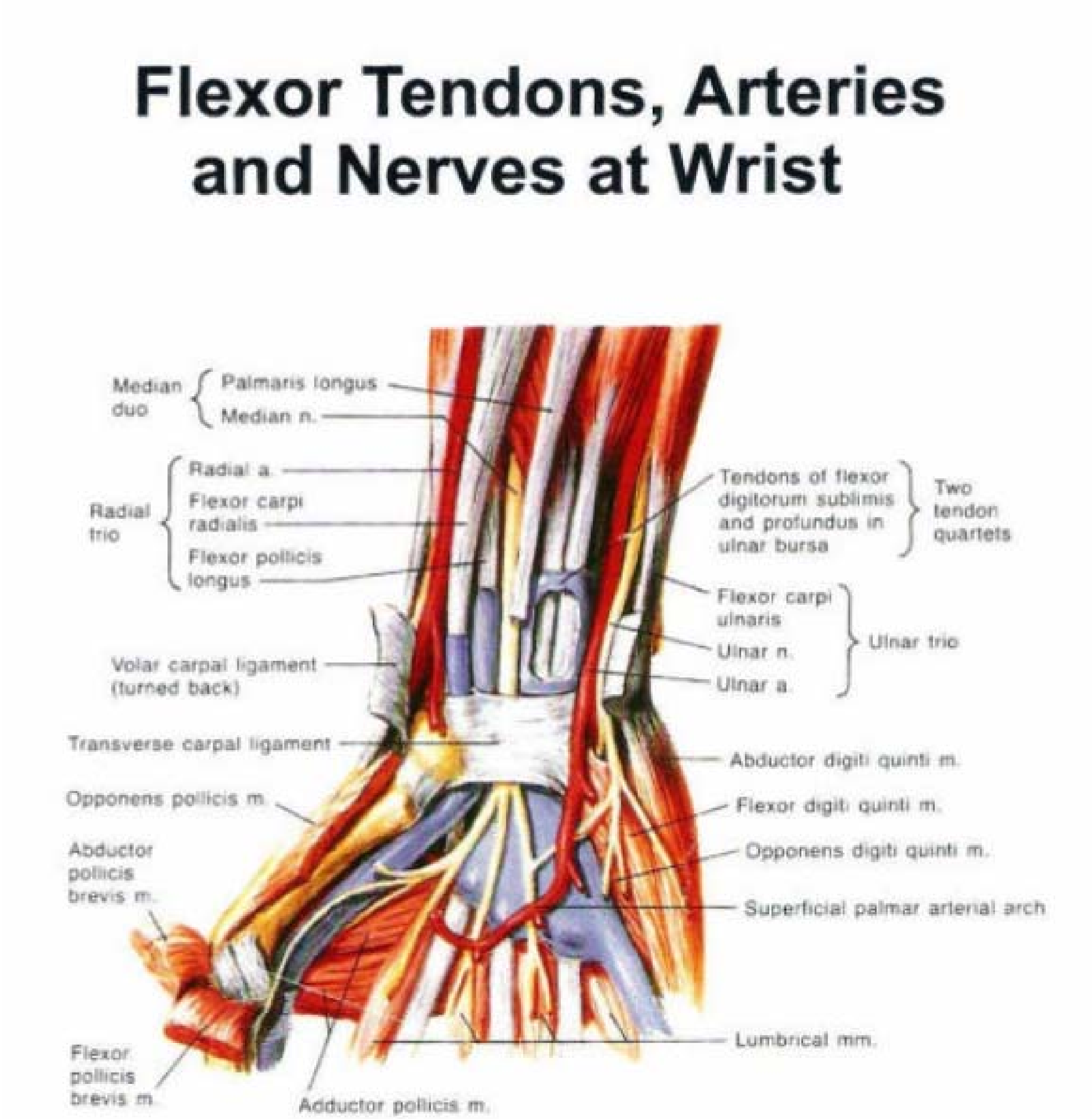
## Muscular anatomy:

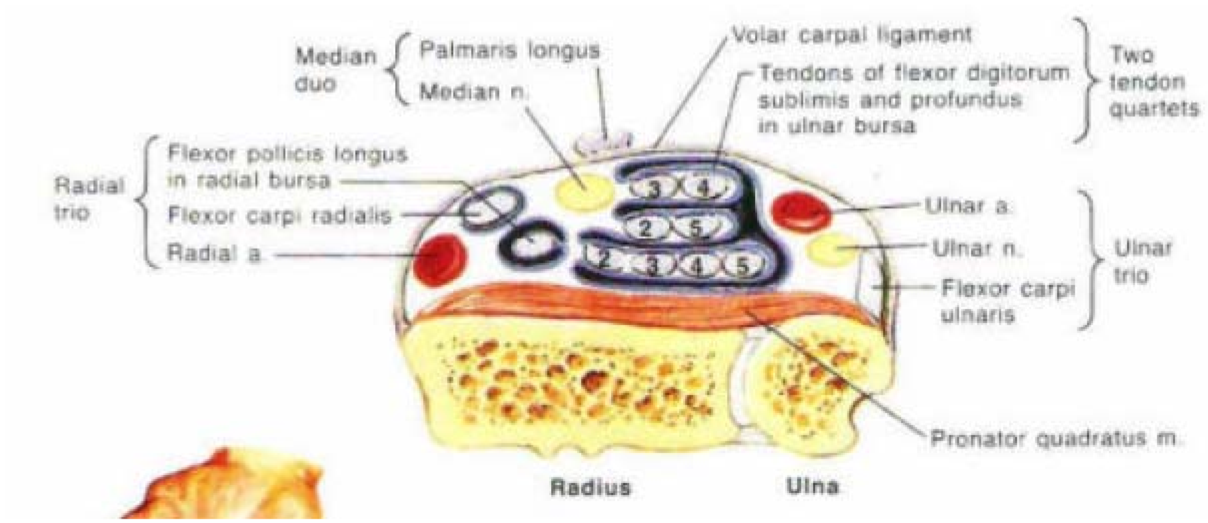
The muscles of importance in the distal end of radius are pronator quadratus and extensor carpi ulnaris which are the two dynamic stabilizers of the distal ulna. The pronator quadratus has a superficial head, which is a prime mover for forearm pronation, and a deep head, which helps stabilize the DRUJ. The pronator quadratus actively stabilizes the joint by coapting the ulnar head in the sigmoid notch, particularly in pronation, and passively stabilizes the joint by viscoelastic forces in supination.

The ECU musculotendinous unit has unique features that lend additional stability to the DRUJ complex. Spinner and Kaplan[39] and Taleisnik et al demonstrated how the ECU is maintained in its position over the dorsal distal ulna by a separate fibroosseous tunnel deep to and separate from the extensor retinaculum and its significance in distal radioulnar stability by the bowstring effect. Brachioradialis is inserted into the radial styloid raising concern in comminuted fractures where radial styloid is seen as a separate fragment.

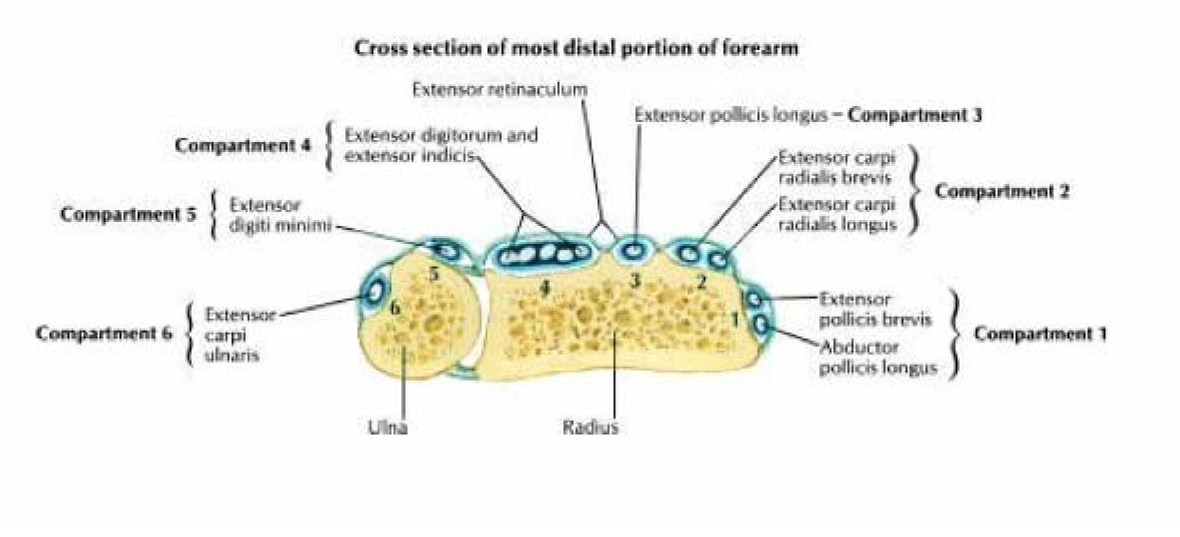
The flexor tendons related to the anterior aspect of the distal radius are flexor carpi radialis, palmarislongus, individual tendons of flexor digitorumsuperficialis and profundus.

The other extensor tendons on the dorsal aspect of the distal radius are abductor pollicislongus, extensor pollicisbrevis, extensor carpi radialisbrevis and longus, extensor pollicislongus and extensors to digits and indicis.






Anterior relations to the Distal Radius and Ulna

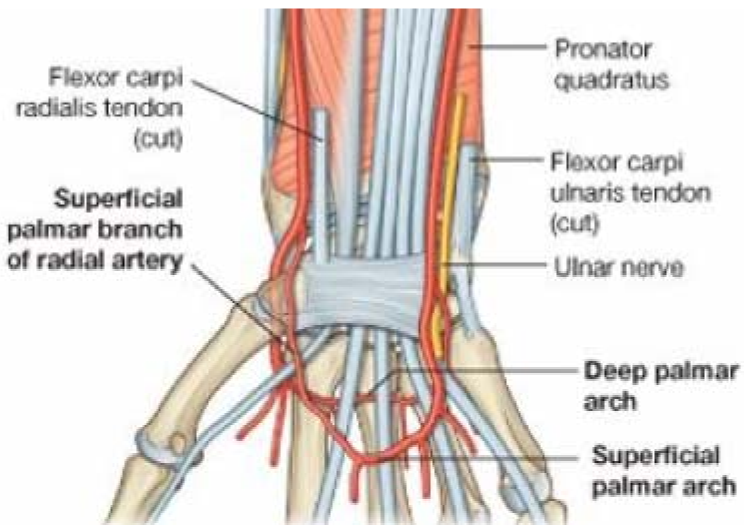



Posterior relations to the Distal Radius and Ulna

## Neuro vascular anatomy:

The radial artery lies anterior to the pronator quadratus muscle and the distal end of the radius lateral to the flexor carpi radialis muscle. It leave sthe forearm by winding lateral to wrist. The radial pulse can be felt by gently palpating the radial artery against the underlying muscle and bone.

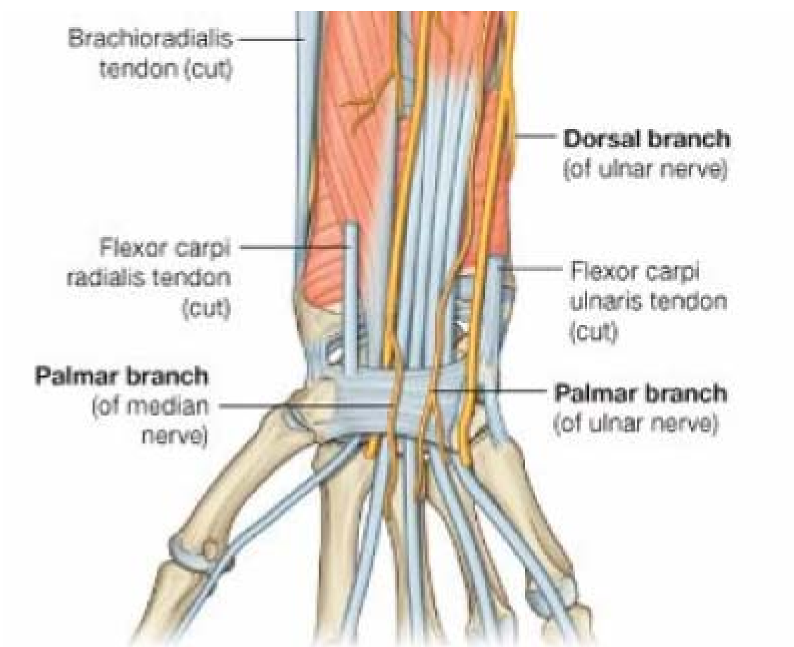
The ulnar artery often remains tucked under the anterolateral lip of the flexor carpi ulnaris tendon and enters the hand by passing lateral to the pisiform bone and superficial to the flexor retinaculum of the wrist, and arches over the palm.




The median nerve becomes more superficial in position at the level of the distal radius, lying between the tendons of the palmarislongus and flexor carpi radialis muscles. It leaves the forearm and enters the palm of the hand by passing through the carpal tunnel deep to the flexor retinaculum.

The ulnar nerve lies lateral to flexor carpi ulnaris nerve and enter the hand by passing superficial to the flexor retinaculum, medial to ulnar artery and immediately lateral to the pisiform bone.

The superficial branch of the radial nerve lies on the lateral aspect of the wrist in close association with the brachioradialis tendon.



# MECHANISM OF INJURY

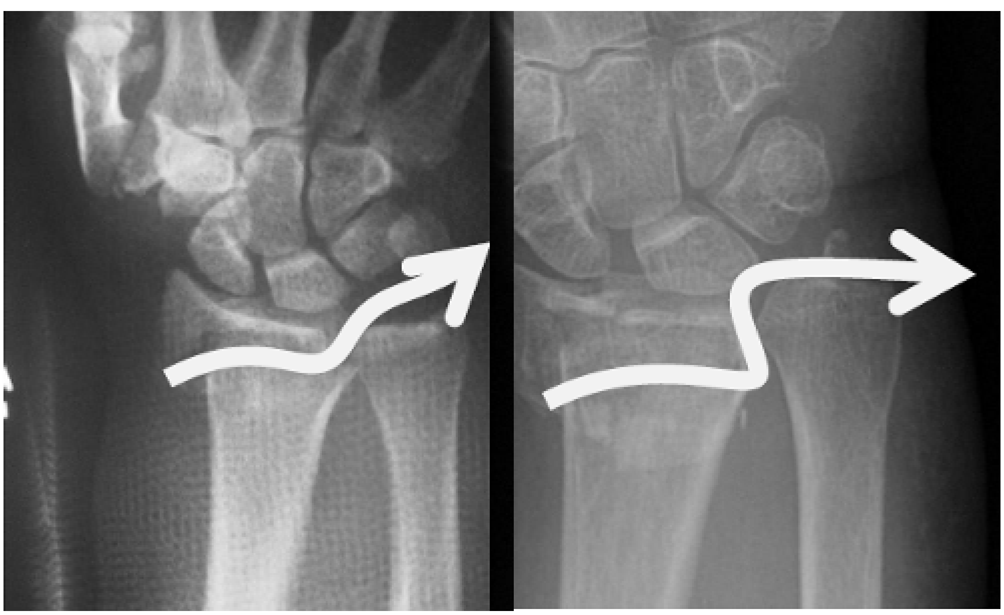
Distal radius fractures usually occur after a fall on an outstretched hand with wrist in dorsiflexion. The type is determined by the rate, magnitude and the direction of the load. The position of the hand at the time of the injury and the bone quality also determines the fracture pattern to some extent.

Shearing forces over the distal radius by the carpal bones at an inclined angle during the fall leads to partial articular fractures. Volar and dorsal Barton fracturesare due to such shear forces exerted by the lunate over the distal radius during fall on outstretched hand. Radial styloid fracture occurs by the scaphoid eccentrically loading on the radial column of the distal radius[5,41]. These fracture types are not usually associated with ulnar styloid fractures.

Avulsion typesof fractures occur by the indirect transmission of the tensile forces exerted over the bone by the ligaments[41]. Volar radio carpal ligaments or the radial collateral ligament do avulse the bony fragments as the force dictates. These fractures do rarely cause ulnar styloid fractures.

A fall on the outstretched hand with the wrist joint in 40° to 90° of etension produces a dorsally displaced distal radius fracture[11,17]. The radius probably fractures first in tension on its palmar surface, followed by compression on the dorsal surface, resulting in dorsal comminution. This is explained by the bending or incurvation theory. Loading at 70* to 90* of dorsiflexion results in highly comminuted distal radius fractures, while those at lower angles (20* to 40*) of extension results in minimal comminution. Dorsiflexion more than 90* at the time of impact results in carpal injuries[11]. The ulnar styloid fracture component of the Colles' fracture results from a force transmitted through an intact triangular fibrocartilage complex at a higher magnitude of force and at higher degrees of dorsiflexion. It is usually associated when the dorsal displacement is 32* or more from the anatomical position.

## DRUJ mechanisms:

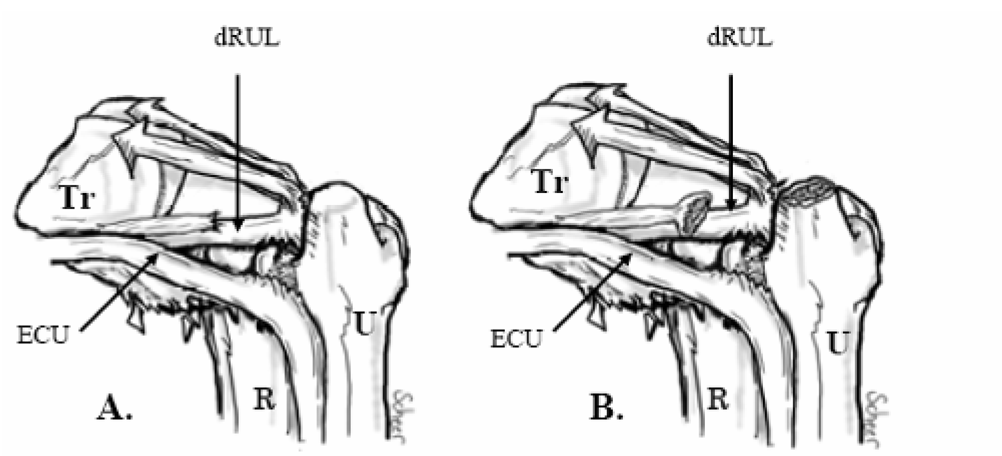


TFCC tear

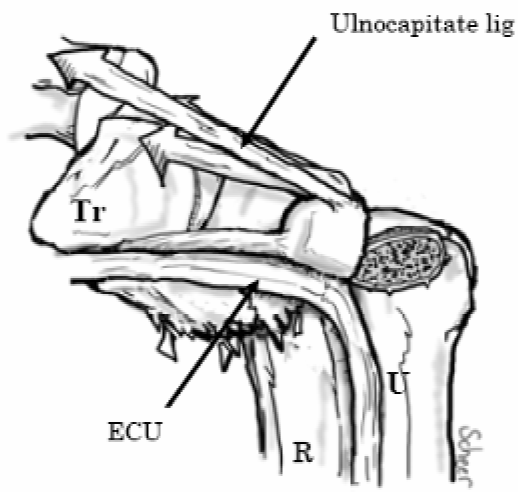
Basistyloid fracture

.

The progressive dorsal angulation and displacement but with lessmagnitude leads to extensor carpi ulnarissubsheath rupture followed by ulnar syloid tip fracture due to ulnotriquetral ligament avulsion. With greater magnitude of force the palmar ulnocarpal ligaments namely ulnotriquetral, ulnolunate and ulnocapitate ligaments pulls forcefully exceeding the bowstringing of ECU leading to basal fracture of ulnar styloid process starting from the palmar side[18].




ECU subsheath rupture
A: ulnar styloid intact. B: Ulnar styloid tip farcture




Base of ulnar styloid process fracture

Compression forces are predominant in high-energy, axial loading injuries and lead to impaction of articular fragments[41]. These types of fractures are usually associated with interosseous membrane rupture in case of pure axial force and base of ulnar styloid fracture if dorsal angulation force is associated.

# MATERIALS AND METHODS

This study was designed to review the Short Term Functional and Radiological outcomes of the treatment of fracture both bones distal forearm by Internal fixation of both the distal ulna and distal radius.

From May 2011 to Nov 2012, 28 consecutive fractures of distal ulna with distal radius in skeletally matured patients were managed primarily by internal fixation with Locking compression plate, Kirschner wire, External fixator, Ellis plate, T plate, tension band wiring, Lag screw or a combination of these. The criteria for patient selection were as follows;

## INCLUSION CRITERIA:

1. Age more than 18 years.
2. Fractures involving both the distal radius and distal ulna with in 5 cm for the joint line.
3. Muller's type II B (unstable) and type III B (potentially unstable) distal ulna fractures.
4. Fractures under Frykman classification II, IV, VI, VIII
5. Closed fractures.
6. Associated distal radius fracture.

## EXCLUSION CRITERIA:

1. Age less than 18 years.
2. Isolated distal ulna or distal radius fractures.
3. Undisplaced fracture.
4. All open fractures.
5. Neglected fractures more than 3 weeks.
6. Severe co-morbidities.
7. Unco-operative and unwilling patient.
8. H/O previous wrist pathology or malunited distal radius fracture.

Patients of both sexes were recruited in the study according to the devised inclusion and exclusion criteria.

## PATIENT EVALUATION:

Patients presenting in the Emergency department and the Outpatient department were admitted for thorough evaluation. Detailed history taking was done to ascertain the duration of injury, mode of injury, co morbid illness, and history of previous surgeries and for ruling out any kind of head injury or other system involvement.

Detailed and thorough clinical evaluation was done for the patient as a whole and the limb in specific. General examination of the patient and complete skeletal survey evaluating the clavicle, chest, whole spine, pelvis and all long bones was done. Systemic examination of cardiac, respiratory, abdominal and neurological functions was done.

The involved limb is evaluated for the injuries pertaining to skin in the form of abrasions, contusion, lacerations, punctured wounds etc. Diagnosis of fracturewas done clinically with the help of tenderness, swelling, deformity and abnormal mobility (rarely). Vascular examination of the distal forearm, hand and palpation of radial artery and ulnar artery pulses in particular were done. Neurological examination of all peripheral nerves is done with particular attention to Median nerve considering its propensity to get injured because of its anatomical position.

Careful evaluation of the features of impending or established compartment syndrome was done for ruling out those fractures from the study. Specialist opinion to rule out other injuries was got. All eligible patients fulfilling our inclusion criteria were subjected to further radiological evaluation.

## RADIOLOGICAL EVALUATION:

Standard posteroanterior and lateral views[22] were taken to assess fracture pattern and to assess the parameters like palmar tilt, radial height, radial inclination, displacement and involvement of radiocarpal and distal radio ulnar joints.

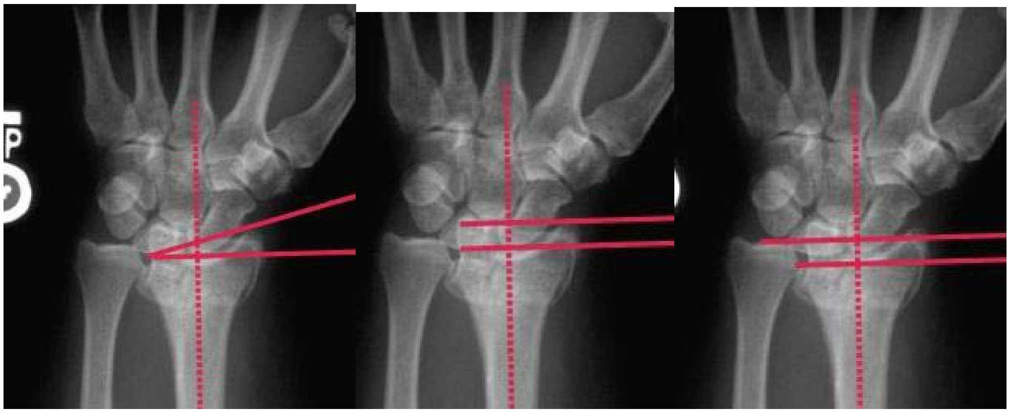
**1. Radial angulation or inclination –** angle betweeen the distal radial articular surface to a line drawn at right angles axis of the radial shaft. Average is about 23 degrees (range 15 to 25 degrees).

2. **Radial length –** distance between two perpendicular lines to the long axis of the radius, one at the tip of the radial styloid process and the other at the surface of ulnar head. Average is 11 mm (8 to 18 mm).

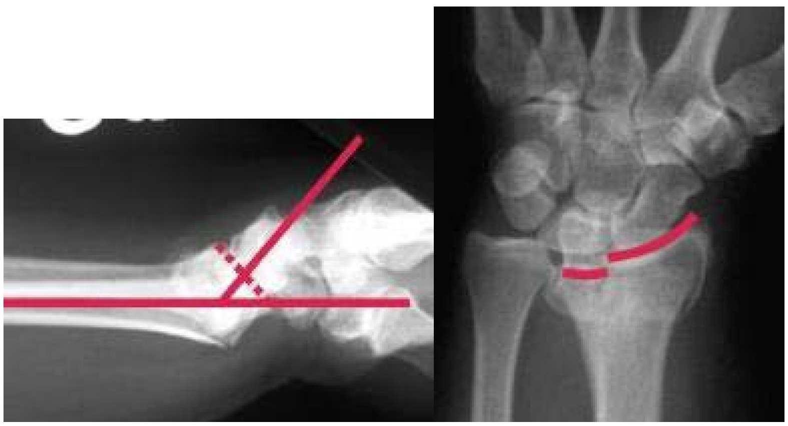
3. **Ulnar variance –** is the vertical distance between the distal ends of the medial corner of the radius and the lateral corner of the ulnar head.

4. **Radial Shift (Width) –** is the amount of displacement of the distal fragment. It is measured between the longitudinal axis of the centre of radius and the lateral point of the radial styloid.

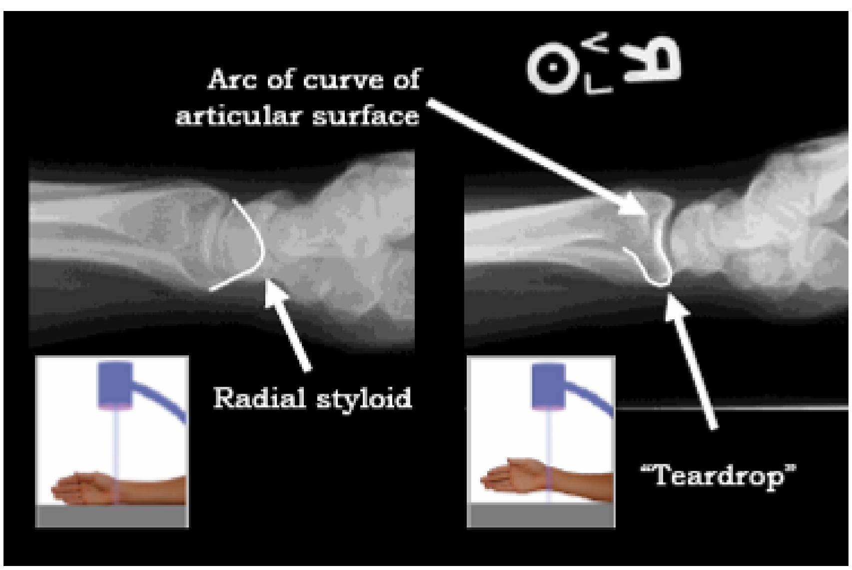
5. **Palmar tilt** – is the relative angle of the distal radial articular surface in relation to the radial shaft in coronal plane. This averages about 11 degrees.



Radial inclination Radial height Ulnar variance



Palmar tilt (Dorsal tilt illustrated) Articular step




Standard and tilted lateral views

The tilted lateral view[40] was also taken which is a lateral view taken with a pad under the hand to incline the radius 22* toward the beam. It eliminates the shadow of the radial styloid and provides a clear tangential view of the lunate facet in assessing the depression of the palmar lunate facet.

Oblique views with the wrist in 45* supination and pronation help in visualizing the fracture lines more clearly.

X rays taken with the wrist in manual traction are the most accurate in describing the fracture pattern. Traction restores the gross anatomy of the limb and reduces overlap.

### Computed Tomography:

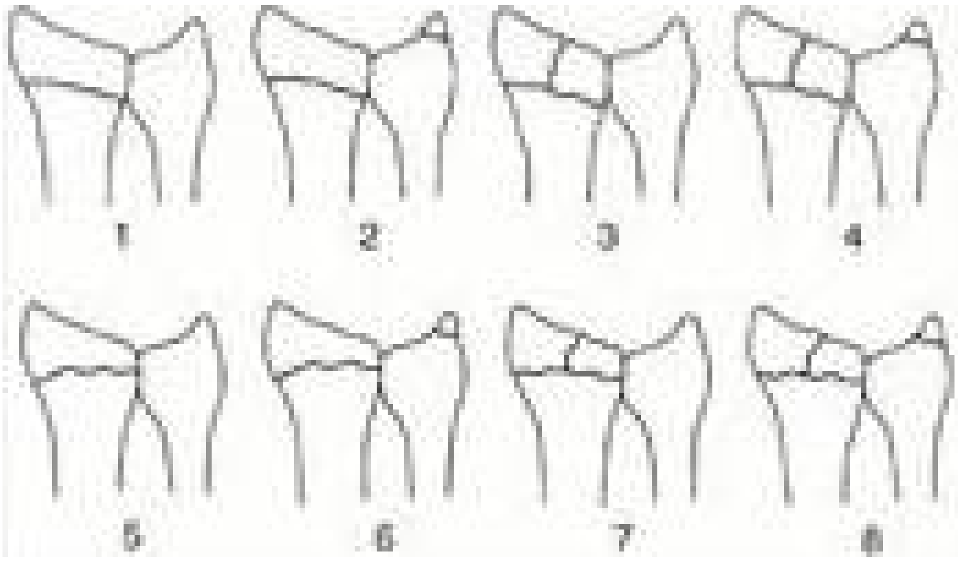
CT scans have joined the armamentorium of investigations in distal radius fractures. They provide the best assessment of articular surface depression, comminution and displacement.  In few numbers of cases with suspicion of severe comminution and displacement CT of Wrist with 3D reconstruction was done. Radiographic classification was done.

## CLASSIFICATION:

Various classifications had been described in the literature for the distal radius fractures. We considered the classifications that included the distal ulna for practical purposes of our study.

**F**rykman first described distal ulna fractures associated with distal radius fractures. He established an eponymous classification system[17], which defines the fracture as intra-articular or extra-articular. It also describes the involvement of radiocarpal and distal radioulnar joints along with the presence or absence of ulnar styloid process fracture. This system does not quantitatively assess the degree of comminution, shortening and the initial impact. Hence, the prognostic value is low in suggesting a treatment..

| Type | Fracture |
|---|---|
| I | Extraarticular radial fracture |
| II | Extraarticular radial fracture with an ulna fracture |
| III | Intraarticular fracture of the radiocarpal joint without an ulna fracture |
| IV | Intraarticular radial fracture with an ulna fracture |
| V | Fracture of the radioulnar joint |
| VI | Fracture into the radioulnar joint with an ulnar fracture |
| VII | Intraarticular fracture involving radiocarpal and radioulnar joints |
| VIII | Intraarticular fracture involving radiocarpal and radioulnar joints with an ulnar fracture |




Frykman classification of Distal Radius fractures.

Fernandezproposed a mechanism-based classification system that would address the potential for ligamentous injury and thereby assist in treatment recommendations[41].

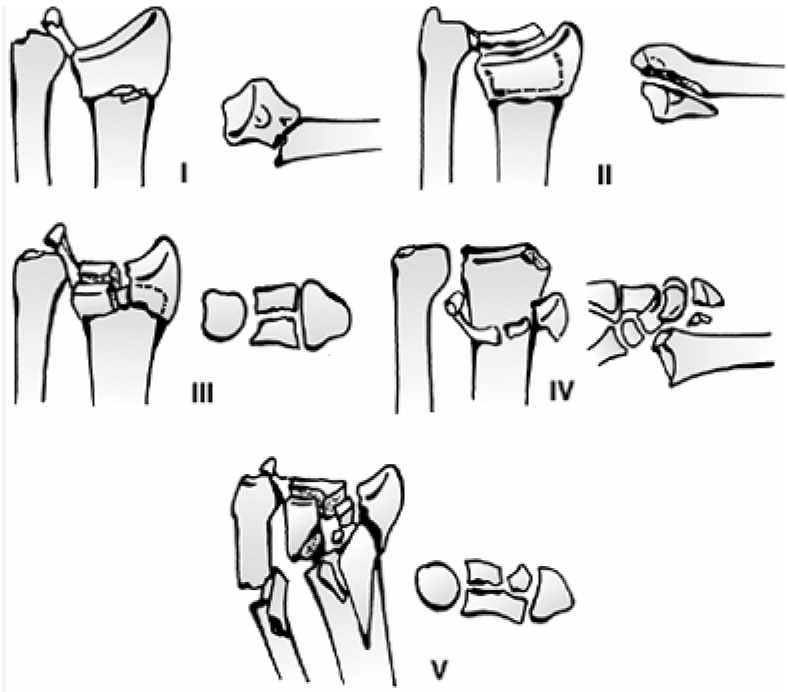
Type I: Metaphyseal bending fractures with the inherent problems of loss of palmar tilt and radial shortening relative to the ulna (DRUJ injuries).

Type II: Shearing fractures requiring reduction and often buttressing of the articular segment.

Type III: Compression of the articular surface without the characteristic fragmentation; also includes the potential for significant interosseous ligament injury.

Type IV: Avulsion fractures or radiocarpal fracture dislocations.

Type V: Combined injuries with significant soft tissue involvement due to the high-energy nature of these fractures.




AO developed the Comprehensive Classification for Long Bone Fractures. The distal radius and ulna are designated as 23 and is further classified into three types as given below.

23A – Extra-articular Fracture

A1 – Extra-articular fracture of the ulna, radius intact.

A2 – Extra-articular fracture of the radius, simple and impacted.

A3 - Extra-articular fracture of the radius, multifragmentary.

23B – Partial articular fracture wherein the fractures involve only part of the articular surface, while rest of that surface remains attached to the diaphysis.

B1 – Partial articular fractures of the radius, sagittal.

B2 – Partial articular fracture of the radius, dorsal rim (Barton).

B3 – Partial articular fracture of the radius, volar rim (reverse Barton).

23C – Complete articular fracture, wherein, the articular surface is disrupted and completely separated from the diaphysis.

C1 – Complete articular fracture of the radius, articular simple, metaphyseal simple.

C2 – Complete articular fracture of the radius, articular simple, metaphysealmultifragmentary.

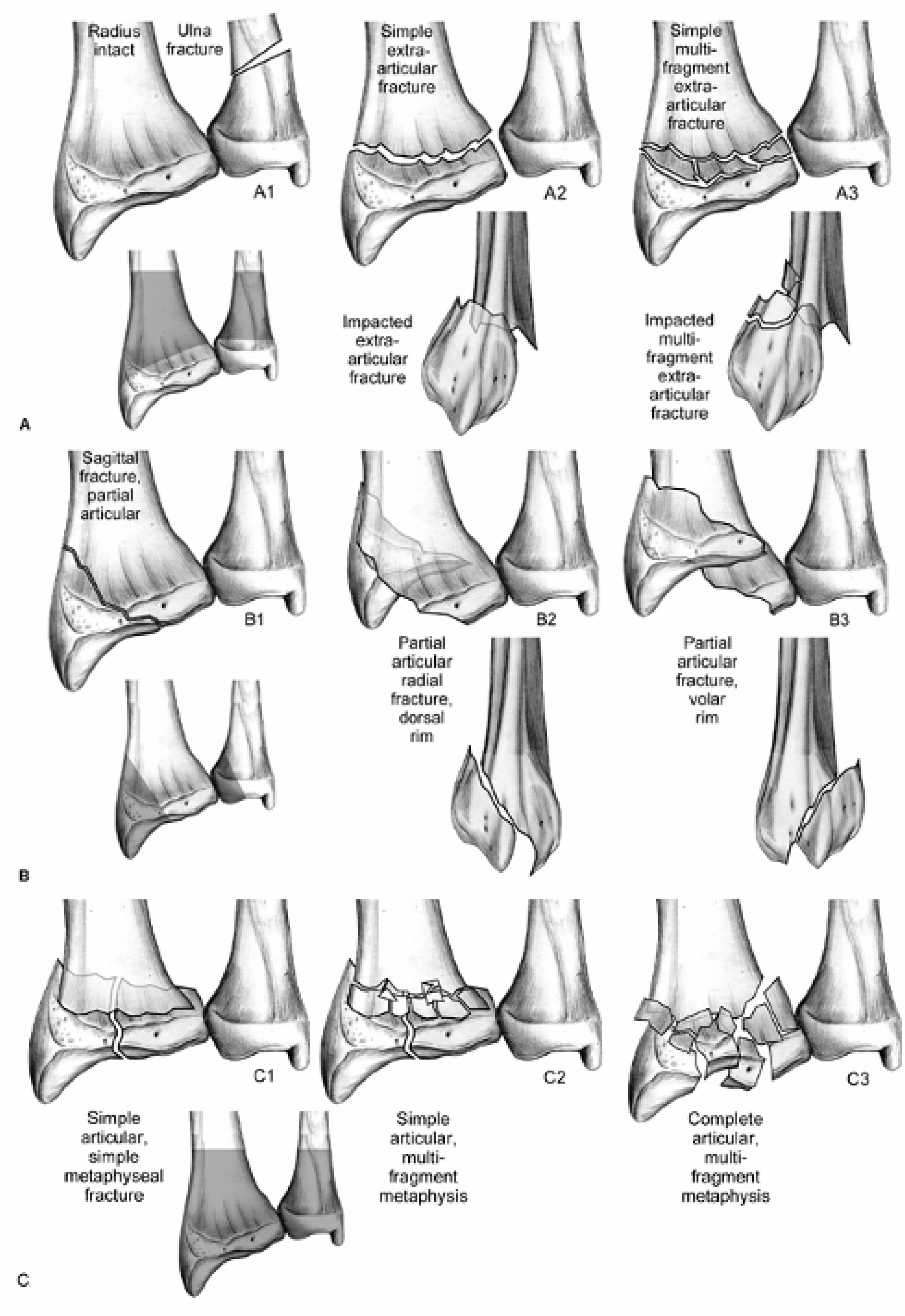
C3 – Complete articular fracture of the radius, multifragmentary.

Modified AO Classification

It is simplified to 5 Intra-articular fractures

A – Extra-articular, B – Partial articular, B1 : Radial Styloid, B2 : Dorsal rim fractures, B3 : Volar rim fractures, B4 : Die Punch fractures, C – Complete articular

The only modification to the AO system was the addition of the "die-punch" fracture to the partial articular fractures group.


Radius intact
Ulna fracture
A1
Simple extra-articular fracture
A2
Simple multi-fragment extra-articular fracture
A3
Impacted extra-articular fracture
Impacted multi-fragment extra-articular fracture
A
Sagittal fracture, partial articular
B1
B2
B3
Partial articular radial fracture, dorsal rim
Partial articular fracture, volar rim
B
C1
C2
C3
Simple articular, simple metaphyseal fracture
Simple articular, multi-fragment metaphysis
Complete articular, multi-fragment metaphysis
C

Muller's classification for Distal Ulna fractures.

| | Pathoanatomy of the lesion | |
|---|---|---|
| **Type I**<br>stable<br>(following reduction of the radius the distal radioulnar joint is congruous and stable) | <br>**A** Fracture<br>Tip ulnar styloid | <br>**B** Stable fracture<br>Ulnar neck |
| **Type II**<br>unstable<br>(subluxation or dislocation of the ulnar head present) | <br>**A** Tear of triangular fibrocartilage complex and/or palmar and dorsal capsular ligaments | <br>**B** Avulsion fracture<br>Base of the ulnar styloid |
| **Type III**<br>Potentially unstable<br>(subluxation possible) | <br>**A** Intra-articular fracture of the sigmoid notch | <br>**B** Intra-articular fracture of the ulnar head |

## PREOPERATIVE WORKUP:

The limb was stabilized in an Above Elbow slab temporarily and limb elevated to reduce the pain and swelling. Further investigations were done for anaesthetist opinion and assessment obtained. All patients included in the study were subjected to the described surgical procedure, after surgical fitness was obtained.

## SURGICAL PROCEDURE:

All internal fixations were performed in the Institute of Orthopedics and Traumatology, RajivGandhiGovernment GeneralHospital& MadrasMedicalCollege, Chennai. The fractures were treated with internal fixation with or without external fixation for both the distal radius and ulna.

### PREOPERATIVE PLANNING

The choice of a particular procedure for each case depended on the fracturepattern, reducibility and stability and quality of bone.The armamentorium of plates for distal radius were T buttress plate, side specific Ellis plate, 3.5 mm locking compression plate, 2.4 mm Locking compression plate, external fixator and Kirschner wires. The choice of implants for distal ulna were 1 mm Kirschner wires, 24G SS wire for tension banding and 1/3$^{rd}$ tubular locking plate.

Various implants 2.4mm LCP, T plate, Ellis palte, 3.5mm LCP, Kirschnerwire.

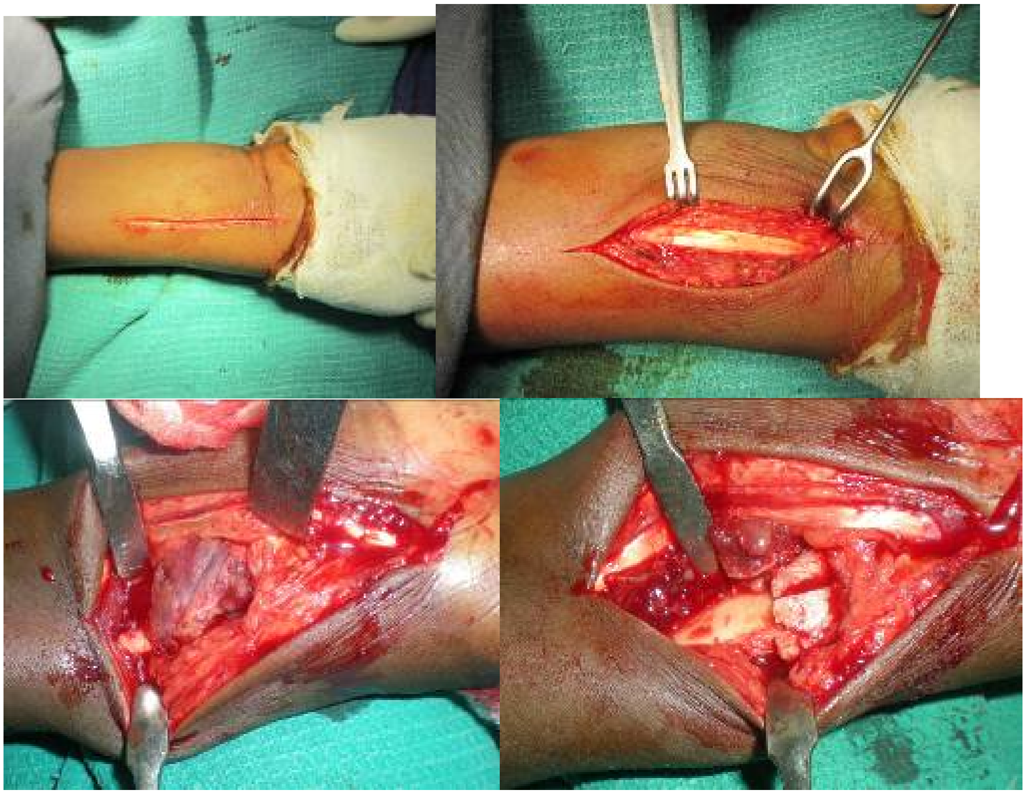
## PATIENT POSITIONING

Patient was positioned supine on the radiolucent table with side arm-board. Image intensifier was positioned under the arm-board so as tovisualise the distal radius, distal ulna and the articular surface in AP and lateral views.

## SURGICAL TECHNIQUE:

All procedures were performed under general or regional anaesthesia (supraclavicular or interscalene block). Our standard practice was preoperative prophylactic intravenous cefotaxime and usage of diathermy for hemeostasis.

The standard volar approach was undertaken to fix the fragments of the distal radius. In cases where the radial column fragment was initially approached, the plane between the radial artery and the flexor carpi radialis was used. For the intermediate column fragment under the lunate facet, plane between the flexor carpi radialis tendon and the median nerve was used. The distal and lateral borders of pronator quadratus were erased and retracted ulnarward.



Intra operative pictures of the Exposure of the Distal Radius

The standard subcutaneous approach was used for the distal ulna for fixation. The surgical plane was between the extensor carpi ulnaris and the flexor carpi ulnaris.

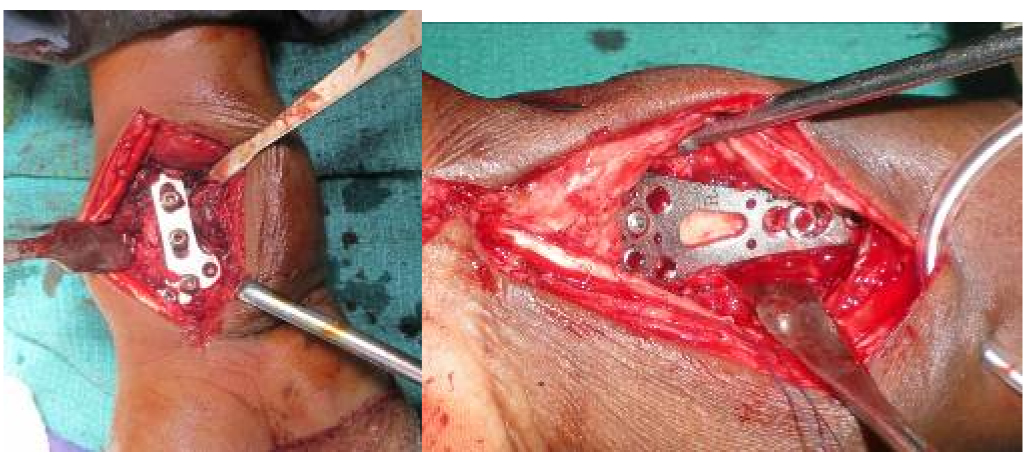
Closed reduction and external fixation was done for those with skin conditions not permitting for open reduction.

Open reduction was performed using intrafocal leverage, traction, and temporary fixation with Kirschner wires followed by definitive fixation with the implants of choice.

In cases which had a displaced radial styloid or fragments too small for other means of fixation, was fixed with Kirschner wires augmented with external fixator or cast immobilization.

Open reduction and internal fixation with T or Ellis buttress plate and screws was done for comminuted fractures with good bone quality. It was also indicated for case which had >2 mm residual articular step-off after reduction.

Locking compression plates with 2.4 mm or 3.5 mm screws were used for comminuted fractures with relatively poor bone quality.



Intra operative picture of Distal Radius with Ellis and LCP

Base of ulnar styloid fractures were fixed with 2 mm lag screw orTension band wiring with two 1 mm Kirshner wire and 24G SS wire.

Ulnar head fractures were treated with 1/3rd tubular Locking plate.

Intra operative picture of Tension Band Wiring of Distal Ulna

## POSTOP PROTOCOL:

All patients were given I.V third generation cephalosporin during induction which was continued for 3-5 days post operatively. The hand and forearm was initially placed in a compressive dressing extending from hand to below elbow and elevated for forty-eight to seventy-two hours to reduce swelling. All patients were encouraged to begin an early active range of motion of the wrist and hand as tolerated. The patients fixed with Kirschner wire alone were immobilized with below elbow cast for three to six weeks based on the bone quality and mobilized thereafter. Sutures were removed on the twelfth post-operative day. Patients were not allowed to lift heavy weight for twelve to sixteen weeks.

## POSTOP RADIOLOGICAL EVALUATION:

Standard posteroanterior and lateral views were taken to assess fracture pattern and to assess the parameters like palmar tilt, radial height, radial inclination, residual deformity. The 22* tilted lateral view was also taken to assess any residual depression of the palmar lunate facet.

The radiological evaluation was performed with

**Sarmiento's modification of Lindstrom's criteria.**

| **Result** | **Deformity** | **Residual dorsal tilt in degrees** | **Radial shortening in mm** | **Loss of radial inclination in degrees** |
|---|---|---|---|---|
| **Excellent** | No or insignificant | 0 | < 3 | < 5 |
| **Good** | Slight | 1 – 10 | 3 – 6 | 5 – 9 |
| **Fair** | Moderate | 11 – 14 | 7 – 11 | 10 – 14 |
| **Poor** | Severe | > 14 | > 11 | > 14 |

## FOLLOWUP EVALUATION:

All patients were reviewed by a single observer. Clinical assessment included time to return to work, presence of wrist pain, range of motion, loss of alignment and radial height and grip strength using gripometer. Radiographs were reviewed monthly for fracture union and to assess fracture alignment. Bony union was defined in both clinical and radiological terms with radiological evidence of bridging trabeculae across the fracture site and disappearance of the fracture line in both posteroanterior and lateral views and clinical evidence of normal activities without pain.

The functional outcome of the patients were evaluated with Mayo Wrist Score.

**Mayo Wrist Score**

Section 1: Pain intensity

- No pain – 25
- Mild occasional – 20
- Moderate, tolerable – 15
- Severe, intolerable – 0

Section 2: Functional status

- Returned to regular employment- 25
- Restricted employment - 20
- Able to work, but unemployed - 15
- Unable to work because of pain - 0

Section 3: Range of motion

| 3a: % of normal side | 3b: If other hand injured | |
|---|---|---|
| 100 % | > 120* | - 25 |
| 75-99 % | 90-120* | - 15 |
| 50-74 % | 60-90* | - 10 |
| 25-49 % | 30-60* | - 5 |
| 0-24 % | < 30* | - 0 |

Section 4: Grip strength - % of normal

| | |
|---|---|
| 100 % | - 25 |
| 75-100 % | - 15 |
| 50-75 % | - 10 |
| 25-50 % | - 5 |
| 0-25 % | - 0 |

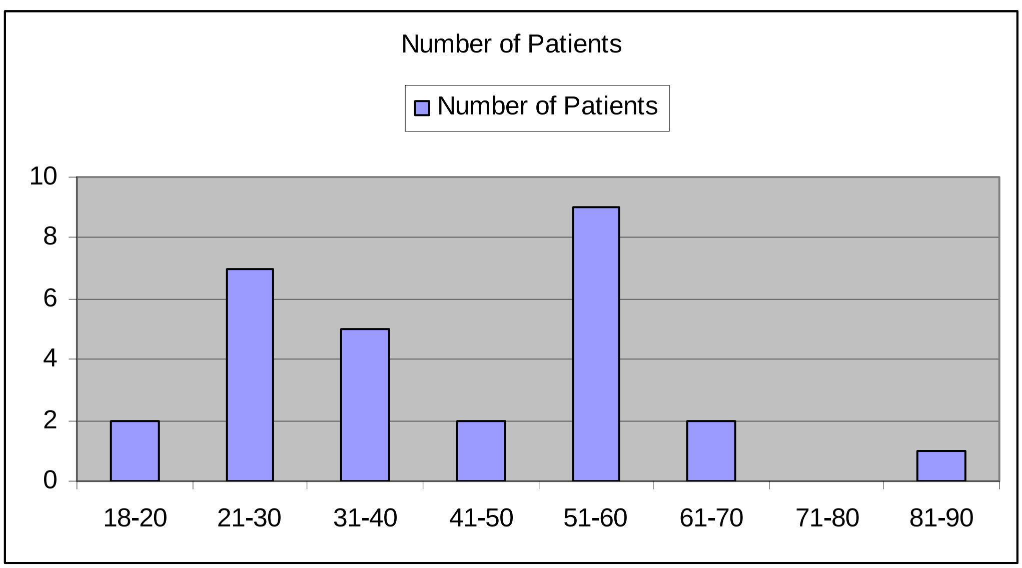
# OBSERVATION AND RESULTS

The following observations were made in the study.

## AGE INCIDENCE:

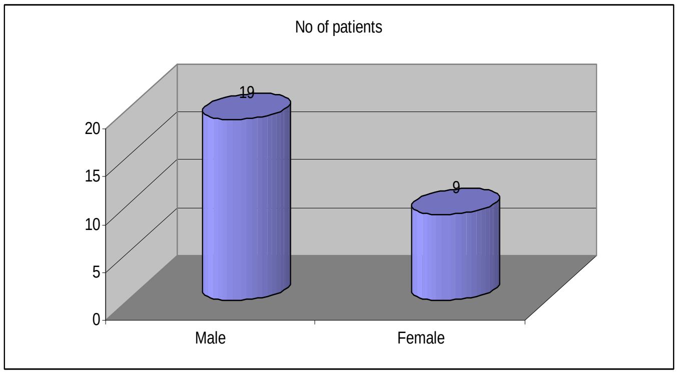
Patients' age ranged from 18 to 82 years. Average: 42.8 yrs

| **Age in Years** | **Number of patients** |
|---|---|
| **18-20** | **2** |
| **21-30** | **7** |
| **31-40** | **5** |
| **41-50** | **2** |
| **51-60** | **9** |
| **61-70** | **2** |
| **71-80** | **0** |
| **81-90** | **1** |
| **Total no of patients** | **28** |



## SEX INCIDENCE:

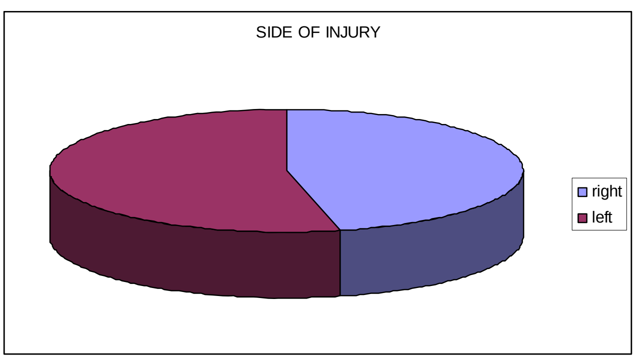
In our series Males predominated with the ratio of 2.1:1




| Sex | Number of patients |
|---|---|
| Male | 19 |
| Female | 9 |

## SIDE OF INJURY

In our study 15 patients had Left sided injury accounting for 54% of the total patients.

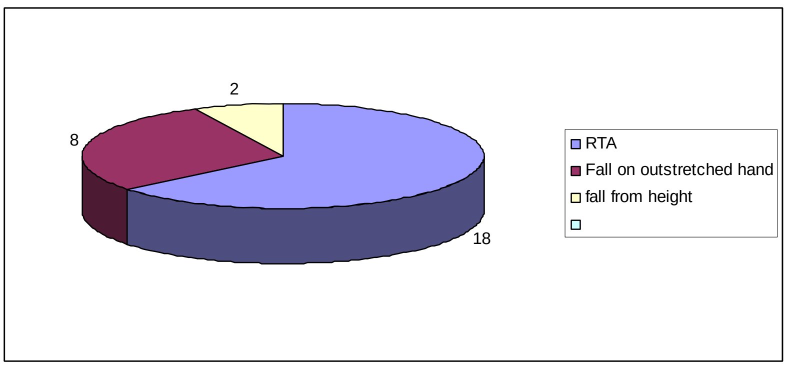



| Side | Number of patients |
|---|---|
| Right | 13 |
| Left | 15 |

# MODE OF INJURY

In our series **RTA** was the predominant mode of injury.

| **Mode of injury** | **Number of patients** |
|---|---|
| **RTA** | **18** |
| **Fall on outstretched hand** | **8** |
| **Fall from height** | **2** |




# FRACTURE CLASSIFICATION

| **Muller's classification** | |
|---|---|
| Type II B | 17 |
| Type III B | 11 |
| **Frykman classification** | |
| Type II | 8 |
| Type IV | 8 |
| Type VI | 6 |
| Type VIII | 6 |

In our study Muller's type II B fractures predominated in 61 % of patients. Frykman's type II fractures was found more common in old age above 50 years and type IV, VI and VIII were found among younger patients.

Only 8 of the 28 patients presented with significant co-morbid illness in the form of Diabetes Mellitus or Systemic Hypertension which were adequately controlled prior to surgery.

All patients belonged to lower socioeconomic strata of the society with moderate built and nourishment.

All closed fractures presented within 3 days from the time of injury.

Twelve patients had associated skeletal injuries which were treated appropriately.

| **Associated injuries** | **Number of patients** |
|---|---|
| # Shaft of femuripsilateral | 2 |
| # Both bones Legipsilateral | 2 |
| # L1 | 1 |
| C5C6 subluxation without neurological injury | 1 |
| # pubic rami | 1 |
| # Olecranonipsilateral | 1 |
| Crush injury contralateral arm | 1 |
| Crush injury leg contralateral | 1 |
| Compartment syndrome of handipsilateral | 1 |
| # Proximal Humerus contralateral | 1 |

None of the patients had any other major organ involvement.

Neurovascular status was intact in all the patients under study.

The average delay in surgery in our study was 4.4 days and the range was 12 hours to 18 days.

Tourniquet was used in eight patients and hemostasis was achieved in all patients using diathermy before closing the surgical wound.

23 patients were approached by standard subcutaneous approach for distal ulna. Five patients were treated by closed reduction technique with Kirschner wire alone.

17 patients were treated with **tension band wiring**for ulnar styloid fracturesand5 patients were treated with 1/3$^{rd}$ tubular locking plate. One patient was fixed with lag screw.

All the patients were approached by standard volar approach for distal radius except for three, where closed reduction was done and external fixator was applied and augmented with Kirschner wire or screws.

Nine patients were stabilized with side specific Ellis plate for distal radius fracture. Seven were treated with Locking compression plate and three with T buttress plate. Six patients were fixed with Kirschner wire only.

| Distal ulna fracture | |
|---|---|
| Tension band wiring | 17 |
| 1/3rd tubular locking plate | 5 |
| Kirshner wire | 5 |
| Lag screw | 1 |
| **Distal radius fracture** | |
| Ellis plate | 9 |
| Locking compression plate | 7 |
| T buttress plate | 3 |
| Kirshner wire | 6 |
| External fixator | 3 |

Average duration of surgery was one hour and ten minutes with range being 40 minutes to 1 hour and 50 minutes.

Average loss of blood during the surgery was 200 ml ranging between 100 to 450 ml.

Bone grafting was **not done** in any of the cases in spite of the higher degree of comminution in high number of patients as all of them had good bone in the volar intermediate column[16].

The reduction of both the distal radius and distal ulna were confirmed with the image intensifier during the fixation and ensured before closure of the surgical site.

Drain was not used in any of our patients.

Mobilization of the wrist and the hand were initiated from the $2^{nd}$post-operative day as tolerated by the patient except for those fixed with External fixator or Kirschner wires alone. Those patients fixed with K wires were initially given below elbow cast and was mobilized by 3-6 weeks, after the removal of the cast.

## RESULTS:

The mean follow up was 8.8 months, range being 4 months to 18 months. 25 of the 28 patients had regular follow-up. Two patients are lost to follow-up after 2 months of surgery due to social reasons. One patient in his ninth decade expired in the second post-operative month following myocardial infarction. Hence results of only 25 patients were analyzed.

UNION:

All the patients had good union.The mean time of union was 13 weeks with a range of 10 to 18 weekswith a majority of 52% healed by 12 weeks. Rest of the 12 cases took a longer duration. No case of delayed union was reported. Longer duration to union is noted in patients of older age with relatively poor bone quality.

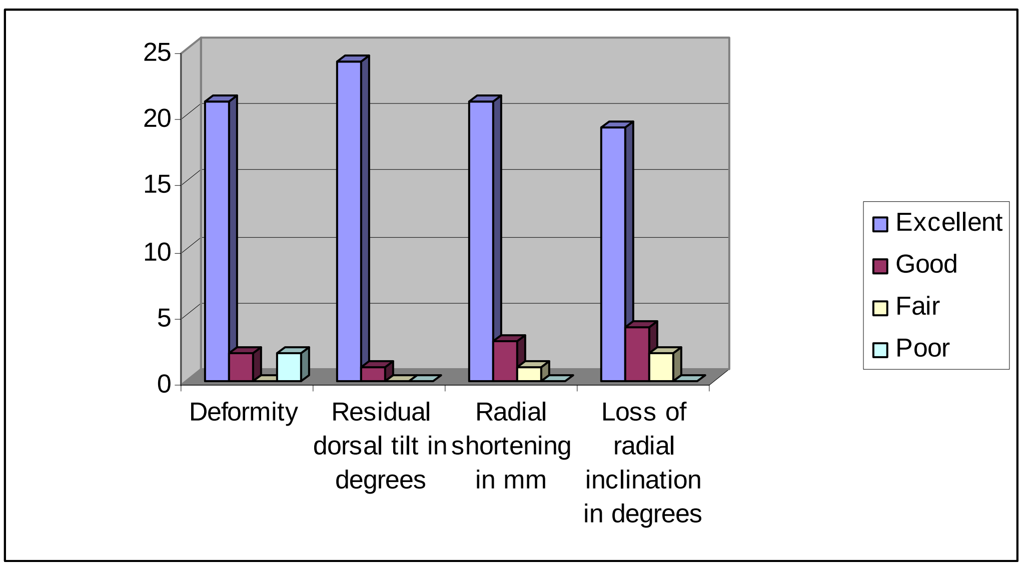
MALUNION:

Two patients who were treated with kirschner wire alone following closed reduction had malunion with significant dorsal angulation with negative palmar tilt.

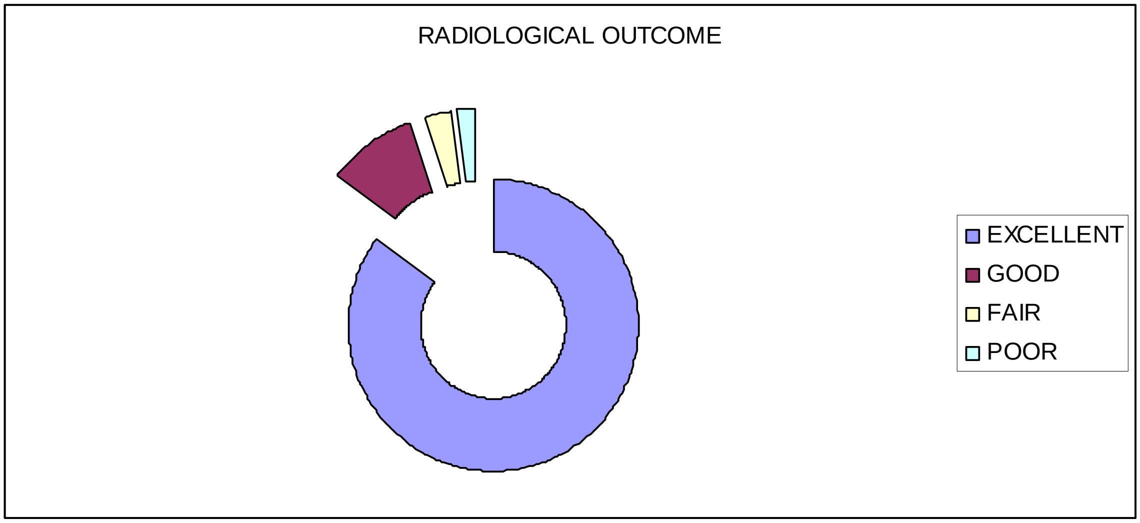
RADIOLOGICAL OUTCOME:

**Sarmiento's modification of Lindstrom's criteria:**

| Result | Deformity | Residual dorsal tilt in degrees | Radial shortening in mm | Loss of radial inclination in degrees | **Mean** |
|---|---|---|---|---|---|
| **Excellent** | 21 | 24 | 21 | 19 | **21.25 (85%)** |
| **Good** | 2 | 1 | 3 | 4 | **2.5 (10%)** |
| **Fair** | - | - | 1 | 2 | **0.75 (3%)** |
| **Poor** | 2 | - | - | - | **0.5 (2%)** |



85% of our patients had excellent radiological outcome based on Sarmiento's modification of Lindstrom's criteria. 10% had good results and less than 1% had fair or poor results radiologically.




Mean range of motion were flexion 70 degrees (60-80*); extension 60 degrees (55-85*); pronation 70 degrees (55-80*); and supination 65 degrees (45-75*); ulnar deviation 25 degrees (20-35*) and radial deviation 15 degrees (10-20*). Grip strength was assessed using gripometer and was on average 85% compared to the opposite normal side with range being 55% to 100%. Rotational movements were on lower side of our observed range in two patients who had malunion. Grip strength and range of motion was found decreased among the older people who were relatively less co-operative for the physiotherapy and those treated with K-wires alone and immobilized in cast for a reasonable period of time.

COMPLICATIONS:

Two of our patients had malunion.

Four of our patients had prominent wires that were felt subcutaneously on the ulnar side. None of the four had any functional disturbance or pain because of the same.

Stiffness of the wrist joint and the hand was noted in four patients who were reluctant in mobilizing and attending physiotherapy sessions.Two patients who were immobilized in cast postoperatively had transient stiffness which was overcome with aggressive physiotherapy resulting in good range of motion thereafter.

One of our patients had superficial infection which warranted early removal of K-wire leading to malunion. The infection was controlled by removal of K-wire and antibiotics.

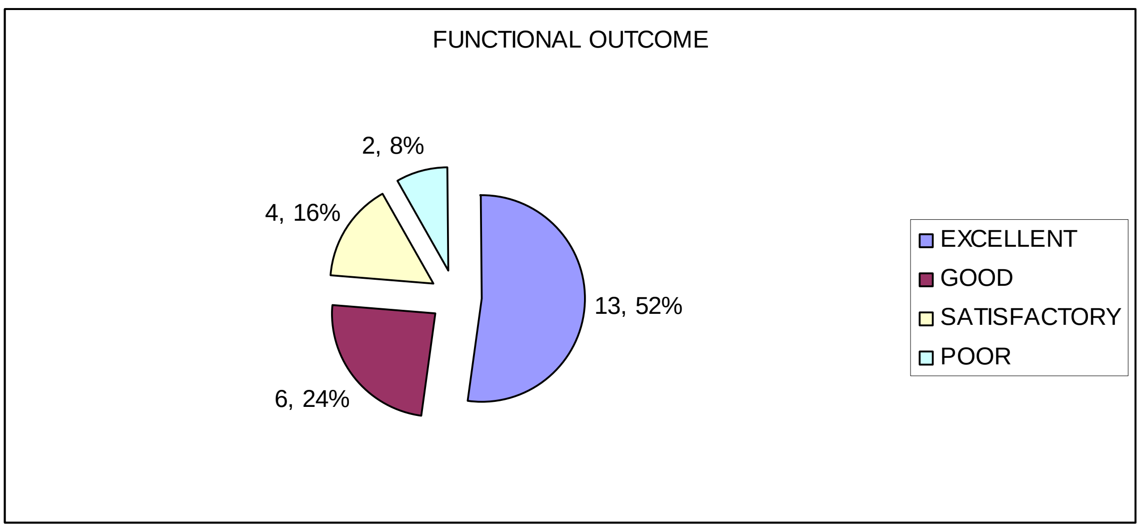
None of the patients in the present study presented with Iatrogenic Neurovascular injury or Implant breakage during the period of follow-up.

**None of the patients had distal radio ulnar instability during the period of follow up**.

FUNCTIONAL OUTCOME:

**Mayo Wrist Score**

| **Result** | **Number of patients** |
|---|---|
| Excellent | 13(52%) |
| Good | 6 (24%) |
| Satisfactory | 4 (16%) |
| Poor | 2 (8%) |



# DISCUSSION

The distal radius fractures had been known and evaluated for centuries. The incidence of distal radius fractures is 17 % of all fractures and 75% of forearm fractures as reviewed in various literatures[24]. The incidence of the intra articular fractures increasing due to rising road traffic accidents. Around 50 - 70% of the distal radius fractures are associated with distal ulna fractures, the exact incidence have not been reviewed in the literature. More than 40% (range 21–61%) of distal radius fractureshave an associated ulnar styloid fracture [31,42,43]. Thisincreases to 86% if the radial fracture is intra-articular[44]. In our study 20 of 28 cases (72%) of distal ulna fractures and 14 of 17 (82%) ulnar styloid process fractures were associated with intra articular distal radius fractures.

The average age was 52 years according to Dennison et al, 73.6 years according to Walz et al where they had given two various fixation techniques for the ulnar head and neck fractures. In our study the average age for ulnar head and neck fractures were 63.5 years. The comparison for average age for distal radius fractures is tabulated below.

| | Minimum age in years | Maximum age in years | Average age in years |
|---|---|---|---|
| John K Bradway et al | 18 | 75 | 40 |
| Jupiter et al | 16 | 76 | 42 |
| Louis Catalano III et al | 17 | 42 | 30 |
| Our study | 18 | 82 | 43 |

The average age of 43 years in our study is comparable to Bradway et al and Jupiter et al who had an average age of 43, 40 and 42 respectively.The average age for ulnar head and neck fractures with associated distal radius fractures was 63.5 years and is comparable to 73.6 years according to Walz et al.

Our study had a male preponderance with 19 cases of 28 cases and is comparable to various studies given below.

| | Males (%) | Female (%) |
|---|---|---|
| John K Bradway et al | 56 | 54 |
| Jupiter et al | 60 | 40 |
| Louis Catalano III et al | 67 | 33 |
| Our study | 68 | 32 |

The higher incidence among males in our study is comparable to Jupiter et al and Louis catalano et al which were 68%, 60% and 67% respectively. The higher incidence among the males would be due to higher involvement in road traffic accidents.

In our study left side (non-dominant) was involved in 54% of cases and is comparable to Walz et al, Louis Catalano et al and Bradway et al's study as given below by tabulation.

| | Right side (%) | Left side (%) |
|---|---|---|
| John K Bradway et al | 50 | 50 |
| Jupiter et al | 61 | 39 |
| Louis Catalano III et al | 48 | 52 |
| Walz et al | 48 | 52 |
| Our study | 46 | 54 |

In our study Road traffic accidents dominated with 64% and is comparable to Jupiter et al and Walz et al study.

| | RTA (%) | Fall on outstretched hands | Others |
|---|---|---|---|
| John K Brad way et al | 31 | 69 | - |
| Jupiter et al | 67 | 33 | - |
| Louis Catalano III et al | 10 | 67 | 14 |
| Walz et al | 70 | 30 | - |
| Our study | 64 | 28 | 8 |

More number of cases in our study is because of RTA and of younger age. This could be explained by fall on outstretched hand in older age causes extra articular fractures with minimal displacement and without involvement of the ulnar side, which were not included in our study.

The type of fracture could not be compared with any series as we have omitted the Frykman's types I, III, V, VII. As comparable to other study more intra articular fractures are seen among the younger individuals. Though numerous classifications have been described for distal radius none of them included the associated distal ulna fractures and graded the severity accordingly.

Various techniques and implants have been used for treating the distal radius fractures. From the days of cast application for all the cases the era changed to pinning and casting followed by external fixator application and indirect reduction of the fracture by the principle of ligamentotaxis. Later buttress plates of various shapes were used for internal fixation[24,28]. The next breakthrough was with the Locking plates which had better anchorage and stability even in the metaphyseal bone[28]. With advancement came the fracture specific smaller plates and anchorage pins[29]. The variable angled 2.4mm locking plates are the newer choice with maximum number of screws in the metaphyseal region in the desired direction of anchorage.

In our study 68% of the distal radius were stabilized by open reduction and internal fixation as compared to Bradway et al's 69% and Louis Catalano et al's 71%. The rest were fixed with pinning or external fixator as comparable to other studies.

The importance of the distal ulna came to be known after the three column concept was proposed byRikkliet al[16]. Later many biomechanical and clinical studies were undertaken for knowing the ulnar column and its significance[38]. It became evident that more load transmission occurred across the ulnar column especially while making fist, which is a basic requisite for a good functional outcome.

Fixation of the ulnar column was stressed for better function of the wrist and to avoid late distal radio ulnar instability[31,32]. Many studies revealed negative outcomes of distal radius fixation with untreated distal ulna fractures. Hence the classification of the distal ulna fractures came to vogue. Even separate classification for ulnar styloid fractures were proposed by Fernandez et al. The level of fracture has implications for management. The ulnar styloid fracture at the tip can be treated conservatively as only few ulnotriquetralfibres would be disrupted. The base of the styloid fractures with greater displacement along the line of the distal radius are to primarily fixed to achieve osteosynthesis to prevent later complications.

The clinical assessment of the distal radio ulnar joint becomes difficult in the emergency room setting. It can be assessed under anaesthesia after rigid fixation of the distal radius.

MRI at the acute stages will be deceiving due to edema and hemarthrosis. Further MRI seems to have less sensitivity in picking up the TFCC tears.

Primary fixation of the distal ulna fractures along with distal radius fixation gives less morbidity to the patients than later complications like distal radio ulnar instability and reconstructive procedures for those[35,37,38].

Many new fixation techniques have started to emerge for distal ulna fixation. Kirschner wire pinning was initiated along with distal radius pinning[38]. Improved biomechanical understandings of the TFCC complex and the ligaments of the wrist led to the implementation of tension band wiring[43] of the ulnar styloid fractures and this provided for early mobilization of the wrist. Later special plates like condylar blade plate[38], hooked locking compression plate for distal ulna were invented and the biomechanical properties of them were studied. Elastic intramedullary nails were also used for fixing distal ulna fractures and claimed to be superior[36].

Various studies of fixation for distal ulna are coming forth. Whatever be the implant used for attaining the osteosynthesis of the distal ulna, it is important to understand the pathomechanics behind the fracture of the distal ulna or the base of the styloid process fracture.

In our study the average palmar tilt was 4.56* degrees (range -5* to 11*), radial height was 9.1mm (4-11mm) and radial inclination was 20.2* (10-23*).

| | Palmar tilt In degrees | Radial height in mm | Radial inclination in degrees |
|---|---|---|---|
| Ring D et al | 8 | - | 21 |
| Dennison et al | 8 | 10 | 20 |
| Our study | 4.6 | 9.1 | 20.2 |

The average range of motion is comparable to other studies as tabulated below.

| | Flexion in degrees | Extension in degrees | Pronation in degrees | Supination in degrees | Ulnar deviation in degrees | Radial deviation in degrees | Grip strength % of opposite side |
|---|---|---|---|---|---|---|---|
| Ring D et al | 48 | 52 | 76 | 70 | - | - | 64 |
| Dennison et al | 59 | 59 | 67 | 72 | - | - | 97 |
| Our study | 71 | 60 | 69 | 65 | 24 | 16 | 86 |

Good functional results have been reported with any modality of treatment in low energy fractures in elderly but the ideal treatment for high energy injuries with associated distal ulna fractures is still being debated. The goals of the treatment are anatomical reduction of the articular surface and achieving distal radio ulnar congruity and early mobilization.

In our study we had 52% of excellent results based on Mayo wrist scoreand are comparable to other studies as tabulated below.

| | Excellent | Good | Fair | Poor |
|---|---|---|---|---|
| John K Bradway et al | 44 | 12 | 44 | - |
| Jupiter et al | 63 | 20 | 17 | - |
| Dennison et al | 80 | 20 | - | - |
| Ring D et al | 24 | 60 | 16 | - |
| Our study | 52 | 24 | 16 | 8 |

Complications were minimal and are comparable with standard studies. We had four patients with prominent wires, one case with superficial infection and four patients with wrist and hand stiffness. Walz et al reported a complication of spontaneous nail extrusion in one patient. Dennison et al reported one case of superficial infection and prominent implants in two patients.

In our study none had distal radio ulnar instability comparable to Dennison et al study of distal ulna fixation with concomitant distal radius fractures, Ring D et al study of condylar blade plate fixation for distal ulna for 24 patients andWalz et al study of distal ulna fixation with elastic nails.

Primary internal fixation of distal ulna along with distal radius facilitates early mobilization and hence earlier return to activities with good range of movements, especially rotations.

# CONCLUSION

From our study, we conclude that

- Primary fixation of the distal ulna fractures along with distal radius fractures is essential for good functional outcome and to avoid distal radio ulnar instability.
- Necessity of new classification for distal radius fractures associated with distal ulna fractures is evident for planning the management and for prognostic evaluation.
- Conservative management or internal fixation with Kirschner wires alone is not sufficient.
- Stable fixation of the distal ulna fractures can be obtained using tension band wiring or lag screw for ulnar styloid process fractures and 1/3$^{rd}$ locking tubular plate for ulnar head and neck fractures.
- Hence the evidence for primary Distal Ulna fixation is more compelling. However long term follow up is needed to further validate our findings.

# CASE ILLUSTRATIONS

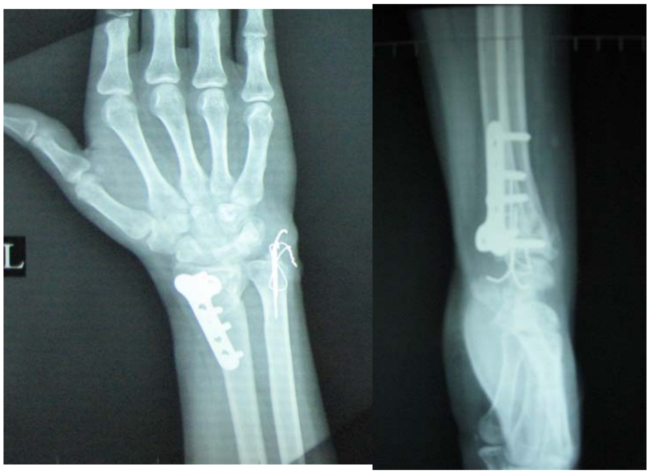
## CASE 1

**Radhakrishnan  23yrs/Male**

Pre op x-ray

Post op x-rays

15 months follow up




Clinical photos

# CASE 2:

**Arumugam 38yrs/ Male**

Pre op x-rays

Post op x-rays

6 months follow up

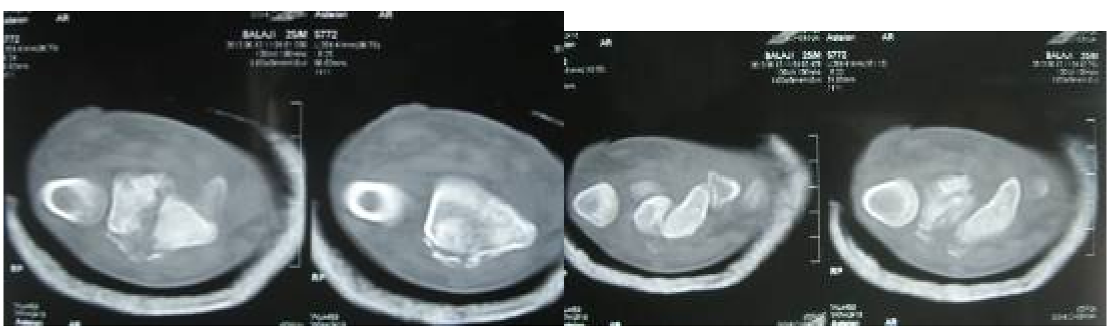

Clinical photos

# CASE 3:

## Balaji 25 yrs/ Male

Pre op x-rays

Pre op CT



Post op x-rays

5 months follow up

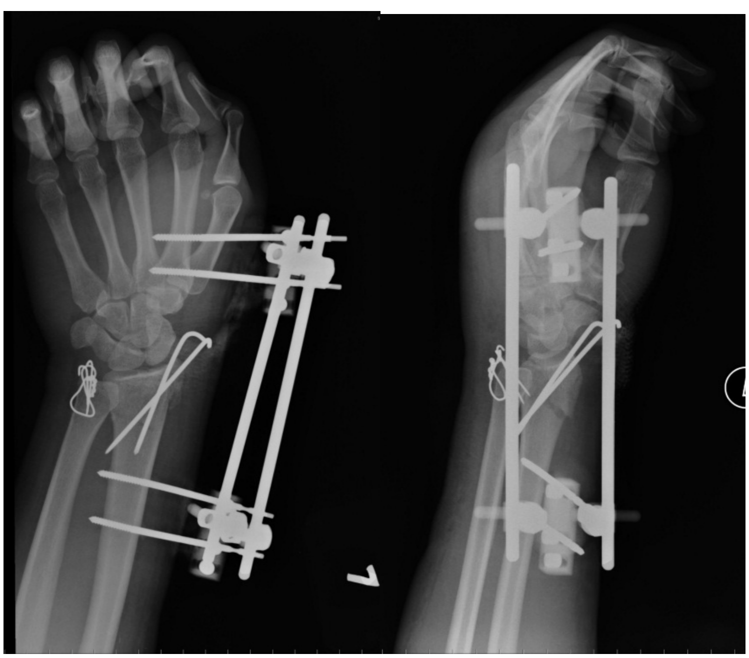

Clinical photos

# CASE 4:

**Sivaram 35yrs/ Male**

Pre op x-rays

Post op x-rays



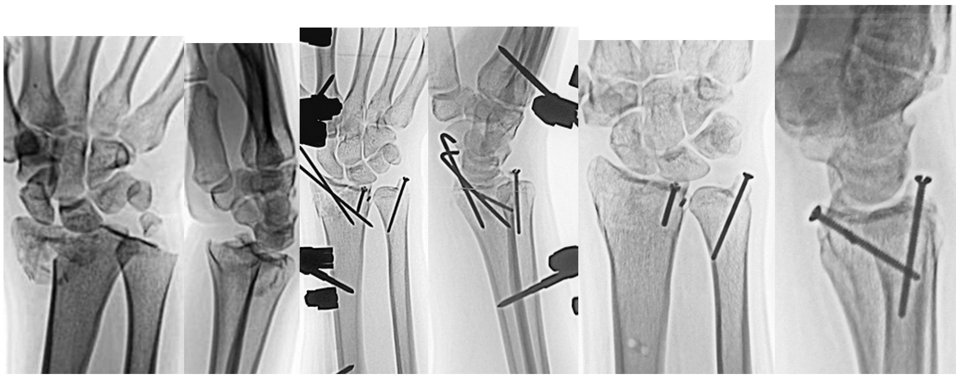
5 months follow up

Clinical photos

## CASE 5:

**Murugan 46/M**

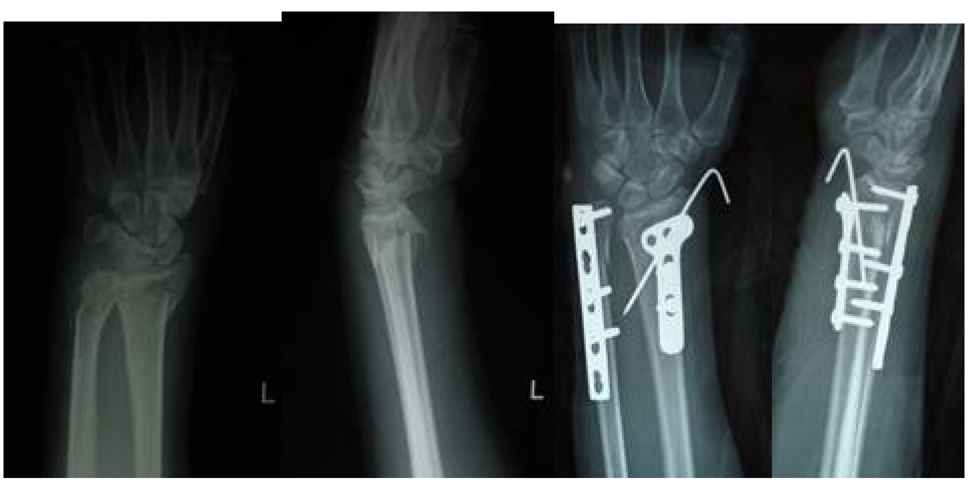
Pre op Post op 5 months follow up



## CASE 6:

**Bhavani 24 yrs/ Female**

Pre op Post op



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# MASTER CHART

| S.no | Name | Age | Sex | IP no. | Side Of injury | Mode of injury | Frykman classification | Muller classification | Associated injuries | Time delay for surgery in days | Surgical procedure | | Follow up (months) | Radiological findings | | | Complications | Mayo wrist score | Functional outcome | Radiological outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Ulna | Radius | | Palmar tilt (*) | Radial height (mm) | Radial inclination (*) | | | | |
| 1 | Radhakrishnan | 23 | M | 7616 | L | RTA | VI | II B | # shaft of femur | 7 | TBW | T plate | 18 | 5 | 10 | 21 | | 95 | Excellent | Excellent |
| 2 | Jeevarthinam | 82 | M | 6836 | L | RTA | II | III B | | 18 | 1/3 LCP | Ellis | Expired | | | | | | | |
| 3 | Sivaram | 35 | M | 7813 | L | RTA | VI | II B | | 1 | TBW | Ex fix k wire | 17 | 11 | 11 | 23 | | 100 | Excellent | Excellent |
| 4 | Bhavani | 24 | F | 9178 | L | Fall from height | VI | III B | # L1 | 9 | 1/3 LCP | Ellis | Lost | | | | | | | |
| 5 | Arumugam | 38 | M | 10985 | R | RTA | II | II B | | 4 | TBW | Ellis | 17 | 5 | 11 | 21 | Prominent wire | 100 | Excellent | Excellent |
| 6 | Murugan | 46 | M | 29176 | R | RTA | IV | II B | | 3 | Screw | Ex fix screw | 15 | 8 | 11 | 23 | | 95 | Excellent | Excellent |
| 7 | Balaji | 25 | M | 48173 | R | RTA | IV | II B | # pubic rami | 3 | TBW | K Wire | 13 | 5 | 10 | 22 | Superficial infection | 95 | Excellent | Excellent |
| 8 | Rathy | 55 | F | 47942 | R | RTA | VIII | III B | # olecranon | 1 | K wire | Ex fix k wire | Lost | | | | | | | |
| 9 | Mohandas | 19 | M | 64217 | R | RTA | VI | II B | Crush injury lt arm | 1 | TBW | Ellis | 10 | 10 | 10 | 22 | | 95 | Excellent | Excellent |
| 10 | Mohan | 18 | M | 64232 | L | RTA | II | III B | Compartment sy left | 1 | K wire | K wire | 10 | 0 | 5 | 20 | Malunion | 45 | Poor | Good |
| 11 | Chandrasekar | 52 | M | 62857 | L | RTA | VI | II B | | 2 | K wire | K wire | 10 | 0 | 10 | 20 | | 95 | Excellent | Excellent |
| 12 | Pappammal | 55 | F | 64917 | L | FOOH | II | III B | | 6 | 1/3 LCP | T plate | 9 | 0 | 6 | 10 | Stiffness | 65 | Satisfactory | Excellent |
| 13 | Nicholas | 21 | M | 68380 | R | RTA | IV | II B | | 2 | TBW | Ellis | 9 | 8 | 10 | 20 | Prominent wire | 85 | Good | Excellent |
| 14 | Veeraraghavan | 55 | M | 85624 | R | RTA | VIII | III B | Crush injury rt leg | 4 | TBW | LCP | 8 | 5 | 8 | 20 | | 85 | Good | Excellent |
| 15 | Krishnamoorthy | 47 | M | 97203 | L | RTA | IV | II B | C5C6 subluation | 6 | TBW | LCP | 8 | 5 | 10 | 15 | | 90 | Good | Excellent |

# MASTER CHART

| S.no | Name | Age | Sex | IP no. | Side Of injury | Mode of injury | Frykman classification | Muller classification | Associated injuries | Time delay for surgery in days | Surgical procedure | | Follow up (months) | Radiological findings | | | Complications | Mayo wrist score | Functional outcome | Radiological outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | Munusamy | 70 | M | 97158 | L | FOOH | VIII | III B | | 15 | K wire | K wire | 7 | -5 | 4 | 10 | Malunion stiffness | 60 | Poor | Fair |
| 17 | Balaji | 24 | M | 106876 | L | RTA | VIII | II B | # proximal humerus rt | 2 | TBW | K wire | 7 | 10 | 11 | 23 | | 95 | Excellent | Excellent |
| 18 | Rani | 55 | F | 103060 | R | FOOH | II | III B | | 7 | TBW | Ellis | 7 | 0 | 8 | 20 | Stiffness | 80 | Satisfactory | Excellent |
| 19 | Lakshmi | 58 | F | 99487 | R | FOOH | II | III B | | 5 | 1/3 LCP | T plate | 6 | 5 | 8 | 13 | | 75 | Satisfactory | Excellent |
| 20 | Settu | 32 | M | 98551 | L | RTA | IV | II B | | 1 | TBW | Ellis | 6 | 6 | 10 | 22 | | 95 | Excellent | Excellent |
| 21 | Meenakshi | 60 | F | 99006 | R | FOOH | II | II B | | 6 | TBW | LCP | 6 | 3 | 10 | 18 | | 90 | excellent | Excellent |
| 22 | Selvi | 32 | F | 102759 | L | Fall from height | IV | II B | # both bone rt leg | 2 | TBW | Ellis | 6 | 3 | 10 | 22 | | 95 | Excellent | Excellent |
| 23 | Kandasamy | 60 | M | 105896 | R | FOOH | IV | IIB | | 4 | TBW | LCP | 6 | 9 | 10 | 22 | | 85 | Good | Excellent |
| 24 | Manjula | 58 | F | 99172 | L | FOOH | II | III B | | 6 | K wire | K wire | 5 | 0 | 6 | 14 | Stiffness | 75 | Satisfactory | Good |
| 25 | Krishnan | 28 | M | 109665 | R | RTA | VIII | II B | # SOF | 1 | TBW | LCP | 5 | 5 | 10 | 21 | Prominent wire | 95 | Excellent | Excellent |
| 26 | Kannammal | 68 | F | 101794 | L | FOOH | VI | III B | | 5 | 1/3 LCP | LCP | 4 | 5 | 8 | 20 | | 85 | Good | Excellent |
| 27 | Murugan | 32 | M | 108896 | R | RTA | IV | II B | # both bones leg | 1 | TBW | LCP | 4 | 5 | 10 | 21 | | 95 | Excellent | Excellent |
| 28 | Ramesh | 29 | M | 118957 | L | RTA | VIII | II B | | 2 | TBW | Ellis | 4 | 6 | 10 | 20 | Prominent wire | 85 | Good | Excellent |

# PROFORMA

## PRE OPERATIVE EVALUATION:

Name:

Age/ Sex:

IP No:

Mode of injury:

Time from injury to admission:

Co-morbid illness:

Associated injuries:

Muller's classification:

Frykman's classification:

Radiological evaluation on presentation:

- Palmar tilt
- Radial inclination
- Radial height
- Deformity
- Articular step

CT finding:

## SURGICAL EVALUATION:

Time from injury to surgery:

Time from admission to surgery:

Duration of surgery:

Position:

Anaesthesia:

Approach:
Radius:
Ulna:

Type of fixation:
Radius:
Ulna:

Blood loss:

Post op immobilization (if any):

## POST OPERATIVE EVALUATION:

Follow up period:

Wound status/ Infection:

Wrist pain:

Distal neuro vascular status:

Union:
Time to union:

Wrist range of motion:
Grip strength:

Radiological evaluation:
Palma tilt:
Radial inclination:
Radial height:
Deformity:
Return to employment: